Willapa Bay Hydrological Analysis Report

1. Introduction: Willapa Bay

Willapa Bay is a coastal watershed located in the Pacific Northwest. This report presents a hydrological analysis of the Willapa Bay basin, focusing on streamflow simulation and model performance evaluation. The simulation was conducted using the CREST hydrological model for the period of 2020-01-01 to 2022-12-31. The analysis is centered on USGS gauge #12010000, located at (46.373994, -123.743482), which is a critical point for monitoring streamflow dynamics within the basin.

2. Basin & Gauge Map

Basin and Gauge Map

This map illustrates the location of the Willapa Bay watershed, including the positions of USGS gauges 12010000 and 12013500. The drainage network and overall basin topography are also visualized. Gauge 12010000 is strategically located near the outlet of Willapa Bay, capturing the integrated streamflow from the upstream drainage area. The map also shows the overall basin topography.

3. Fundamental Basin Data

Fundamental Basin Data

The fundamental basin data provides insights into the topographic and hydrological characteristics of the Willapa Bay watershed. The Digital Elevation Model (DEM) highlights the elevation gradients, ranging from sea level to over 800 meters. The Flow Accumulation Map (FAM) delineates the river channels and their tributaries, indicating the flow pathways and contributing areas. The Drainage Direction Map (DDM) confirms the flow paths towards the bay.

4. Simulation vs. Observation Comparison

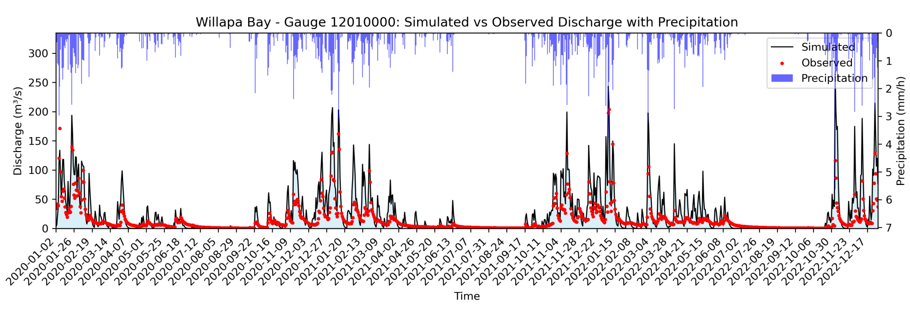

Figure 1: Simulation vs. Observation

This figure presents a comparison between the simulated and observed streamflow at USGS gauge #12010000. The observed discharge (red dots) represents the actual streamflow measurements, while the simulated discharge (black line) reflects the model's output. Precipitation data (blue bars) are also included to illustrate the relationship between rainfall events and streamflow response. The simulated peaks are often higher than the observed peaks, particularly during larger events. There appears to be a slight time lag in the simulated discharge response compared to the observed discharge, with the simulated peaks occurring slightly after the observed peaks in some instances. Additionally, there appears to be a positive bias in the simulation, where the simulated discharge is consistently higher than the observed discharge, especially during baseflow periods.

5. Model Performance Metrics

Metric	Value
Nash-Sutcliffe Efficiency (NSCE)	-0.100
Kling-Gupta Efficiency (KGE)	0.002
Correlation Coefficient (r)	0.882
Bias (m^3/s)	9.91
Bias (%)	69.2
Root Mean Square Error (RMSE) (m^3/s)	23.63

The model performance metrics provide a quantitative assessment of the model's ability to reproduce the observed streamflow patterns. The Nash-Sutcliffe Efficiency (NSCE) of -0.100 indicates a poor model fit, suggesting that the observed mean is a better predictor than the model. The Kling-Gupta Efficiency (KGE) of 0.002 provides a more balanced evaluation, considering correlation, bias, and variability. The correlation coefficient of 0.882 suggests a strong linear relationship between the simulated and observed streamflow. However, the bias of 9.91 m^3/s (69.2%) indicates a systematic overestimation of streamflow. The RMSE of 23.63 m^3/s quantifies the overall error magnitude.

6. CREST Model Parameters

6.1 Water Balance Parameters

Parameter	Value	Unit	Description
Water capacity ratio (WM)	150.0	mm	Maximum soil water capacity
Infiltration curve exponent (B)	5.0	-	Controls water partitioning to runoff

Parameter	Value	Unit	Description
Impervious area ratio (IM)	0.05	-	Represents urbanized areas
PET adjustment factor (KE)	0.8	-	Affects potential evapotranspiration
Soil saturated hydraulic conductivity (FC)	75.0	mm/hr	Rate at which water enters soil
Initial soil water value (IWU)	25.0	mm	Initial soil moisture

6.2 Kinematic Wave (Routing) Parameters

Parameter	Value	Unit	Description
Drainage threshold (TH)	100.0	km²	Defines river cells based on flow accumulation
Interflow speed multiplier (UNDER)	1.5	-	Accelerates subsurface flow
Interflow reservoir leakage coefficient (LEAKI)	0.5	-	Increases interflow drainage rate
Initial interflow reservoir value (ISU)	0.0	mm	Initial subsurface water
Channel flow multiplier (ALPHA)	0.8	-	In Q = A equation; affects channel flow velocity
Channel flow exponent (BETA)	0.6	-	In Q = A equation; affects channel flow velocity
Overland flow multiplier (ALPHA0)	1.0	-	Similar to ALPHA but for non-channel cells; affects overland flow velocity

7. Run Arguments (Basin Details)

Argument	Value	Unit
Basin Area	3282.29	km²
Start Date	2020-01-01	-
End Date	2022-12-31	-
Gauge ID	12010000	-
Gauge Latitude	46.373994	°
Gauge Longitude	-123.743482	°

8. Conclusion and Discussion

The hydrological simulation of Willapa Bay using the CREST model provides valuable insights into the streamflow dynamics of the basin. However, the model performance metrics indicate that the simulation has limitations. The negative NSCE and low KGE values suggest that the model's accuracy needs improvement. The significant positive bias indicates a systematic overestimation of streamflow.

Several factors may contribute to the model's performance. The model parameters, particularly those related to soil water capacity, infiltration, and evapotranspiration, may not be adequately calibrated for the Willapa Bay watershed. The initial soil water conditions could also influence the simulation results. A possible time lag between the simulated and observed hydrographs is another issue.

Given the positive bias of 69.2%, a warmup period is not the primary concern. If the bias was negative and exceeded -90%, then a warmup period would need to be considered to allow the model to stabilize.

Recommendations for future work include:

- **Parameter Calibration:** Conduct a comprehensive calibration of the CREST model parameters using observed streamflow data and possibly other data sources like evapotranspiration estimates.
- **Data Refinement:** Evaluate the accuracy and representativeness of the precipitation data used as input to the model. Consider using higher-resolution or bias-corrected precipitation datasets.
- **Model Structure:** Explore potential improvements to the model structure, such as incorporating more detailed representations of land cover, soil properties, and groundwater processes.
- **Simulation Period:** Extend the simulation period to include a longer historical record of streamflow data for calibration and validation purposes.

By addressing these limitations and implementing the recommendations, the accuracy and reliability of the hydrological simulation for Willapa Bay can be significantly improved.