Willapa Bay Hydrological Simulation Report

1. Title and Basin Information

Basin & Gauge Map

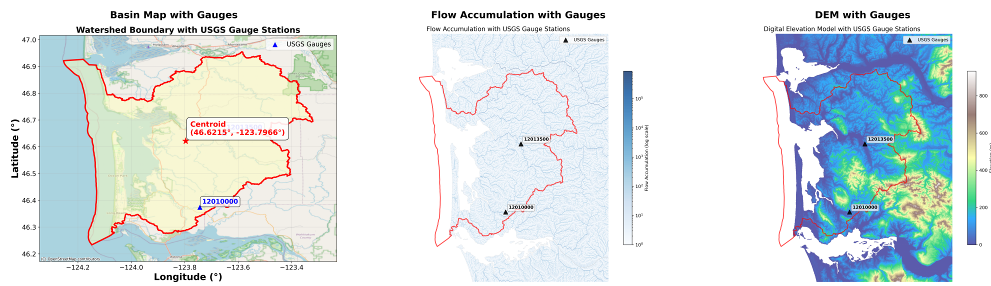

Figure 1: Basin and Gauge Map

Basin Name: Willapa Bay
Area: 3282.29 km^2
Primary Gauge: USGS #12010000 (46.373994, -123.743482)

Fundamental Basin Data

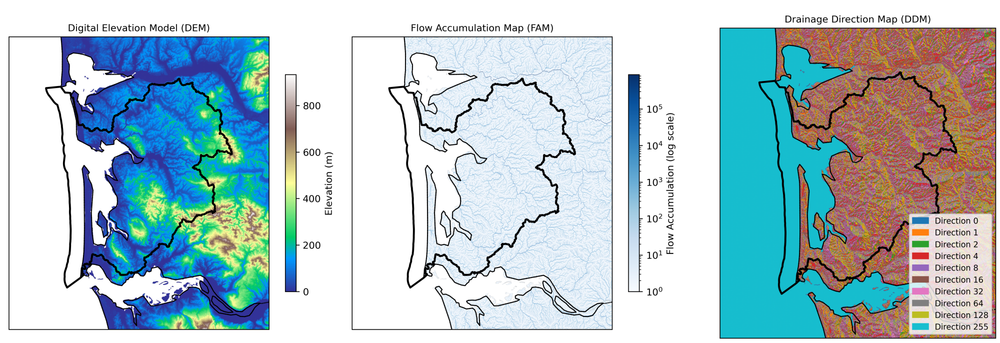

Figure 2: Fundamental Basin Data

- **Digital Elevation Model (DEM):** Elevations range from near sea level to over 800 m, indicating moderate to high relief.
- **Flow Accumulation Map (FAM):** Shows well-defined stream networks draining toward the south and southwest, with high-accumulation corridors near gauge sites.
- **Drainage Direction Map (DDM):** A dendritic drainage pattern flows from uplands to coastal outlets, reflecting a medium to high drainage

density.

Introduction to Willapa Bay

The Willapa Bay watershed lies along the Pacific coast. Its diverse geography includes low-lying coastal plains and higher elevations toward the north and east. The basin's hydrology is largely influenced by maritime climate, receiving significant precipitation during winter months. Gauge #12010000, situated in the southern section, captures primary outflow from the basin.

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2. Analysis Sections

2.1 Simulation vs Observation Comparison

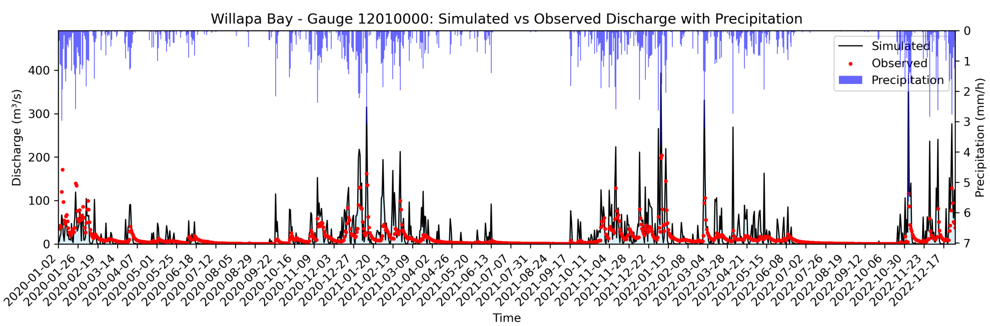

Figure 3: Simulation vs Observation

- **Overall Trends:** The simulated discharge (black curve) follows the seasonal cycle of precipitation (blue bars). Higher flows appear during the wetter winter and spring seasons.

- **Observed Discharge:** The red markers align with simulated peaks but show occasional divergences in magnitude. While the timing of events is generally captured, peak flows are sometimes under- or overestimated.

- **Potential Biases:** Some positive bias is evident in certain high-flow periods. Conversely, some lower flow periods match closely, suggesting the baseflow approach is reasonable.

2.2 Model Performance Metrics

Below are the key performance metrics comparing the daily simulated and observed streamflow at USGS #12010000 for the simulation period 2020-01-01 to 2022-12-31.

Performance Metric	Value
Nash-Sutcliffe Efficiency (NSCE)	-0.992
Kling-Gupta Efficiency (KGE)	-0.058
Correlation Coefficient (Corr)	0.721
Bias (m^3/s, and %)	6.43 (45.0%)
RMSE (m^3/s)	31.80

2.3 CREST Parameters

The CREST model setup for this basin used the following parameter configurations.

Run Arguments (Basin Details)

Argument	Value
Basin Name	Willapa Bay
USGS Gauge ID	12010000
Gauge Coordinates	(46.373994, -123.743482)
Simulation Start	2020-01-01
Simulation End	2022-12-31
Basin Area (km^2)	3282.29

Water Balance Parameters

Parameter	Value	Description
Water Capacity Ratio (WM)	700.0	Maximum soil water capacity in mm. Higher values allow soil to hold more water, reducing runoff.
Infiltration Curve Exponent (B)	1.4	Controls partitioning of water to runoff. Higher values reduce infiltration, increasing runoff.
Impervious Area Ratio (IM)	15.0	Represents urbanized areas. Higher values increase direct runoff.
PET Adjustment Factor (KE)	0.7	Affects potential evapotranspiration. Higher values increase PET, reducing runoff.
Saturated Hydraulic Conductivity (FC)	4.0	Rate at which water enters soil (mm/hr). Higher values allow easier water entry, reducing runoff.

Parameter	Value	Description
Initial Soil Water Value (IWU)	0.2	Initial soil moisture (fraction). Higher values leave less space for water, increasing runoff.

Kinematic Wave (Routing) Parameters

Parameter	Value	Description
Drainage Threshold (TH)	0.8	Defines river cells by flow accumulation (km²). Higher values result in fewer channels.
Interflow Speed Multiplier (UNDER)	0.7	Higher values accelerate subsurface flow.
Interflow Reservoir Leakage Coefficient (LEAKI)	1.5	Higher values increase interflow drainage rate.
Initial Interflow Reservoir Value (ISU)	0.0	Initial subsurface water. Higher values may produce early peak flows.
Channel Flow Multiplier (ALPHA)	0.5	In Q = A^ . Higher values slow wave propagation in channels.
Channel Flow Exponent (BETA)	0.3	In Q = A^ . Higher values also slow wave propagation.
Overland Flow Multiplier (ALPHA0)	0.5	Analogous to ALPHA but for non-channel cells. Higher values slow overland flow.

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3. Conclusion and Discussion

1. **Model Performance Evaluation:**
   - The negative NSCE (-0.992) indicates the current model calibration does not capture flow magnitudes effectively. Conversely, the moderate correlation (0.721) suggests the timing is reasonably represented.

   - The KGE (-0.058) highlights a combination of errors in bias and variability. A 45% positive bias suggests flows are being over-simulated, particularly at higher discharge levels.
2. **Warmup Period Considerations:**
   - While the simulation period spans approximately three years, the model may benefit from a longer warmup to stabilize initial conditions.

- The bias of 45% is well above typical thresholds; although not below -90%, the magnitude of bias still indicates that parameter recalibration could be beneficial.

3. **Recommendations for Simulation Period and Next Steps:**
   - Expand the warmup period by several months to reduce the impact of initial condition uncertainties.
   - Refine parameters related to infiltration (WM, B, KE) and routing (ALPHA, BETA) to address runoff timing and magnitude issues.
   - Investigate subdaily (hourly or 6-hour) time steps if data permits, improving the capture of peak flows and recession rates.
   - Develop additional calibration strategies focusing on low-flow seasons and peak-flow events separately to optimize parameter sets for varied hydrological conditions.

Overall, the CREST simulation for Willapa Bay demonstrates a capacity to track seasonal flow patterns but requires further calibration to improve predictive accuracy and reduce bias. Extending the warmup, refining key parameters, and exploring higher-resolution data are recommended next steps to enhance model performance.