Training SBI for Manning's Value Estimation from Observed Streamflow Data

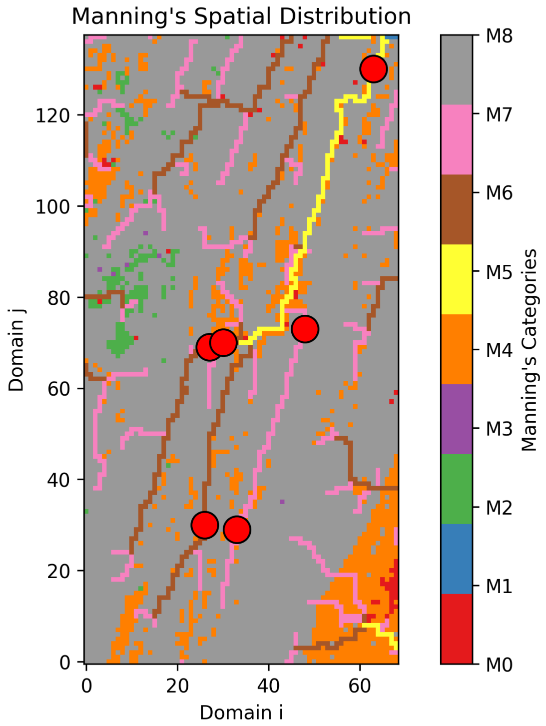
immediate

1. Objective

Generate visual representations to analyze the **posterior density estimation of Manning's value**, given that the observed streamflow data comes from **Hydrodata**.

2. Visualization of HUC 02070001 with Gage Station

The analysis is conducted on the **HUC domain 02070001**, which contains **nine distinct Manning's values**. Figure ?? presents the spatial distribution of these values along with the locations of gage stations within the HUC domain. The gage station data represents streamflow measurements obtained from the **USGS**.



Gage ID	Domain i	Domain j
01605500	26	30
01606000	27	69
01606500	30	70
01607500	33	29
01608000	48	73
01608500	63	130

3. Proportion of Each Manning's value

Calculating the proportion of each Manning's category across the study area can help us determine which roughness type has the largest spatial presence.
Since streamflow is highly sensitive to surface roughness, knowing which Manning's value dominates helps us predict which areas will contribute the most to flow resistance, velocity changes, and discharge variability.

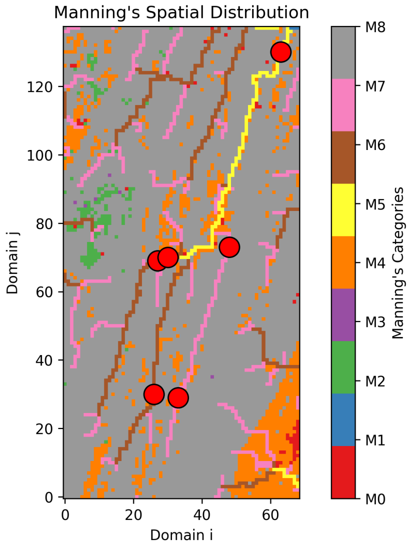


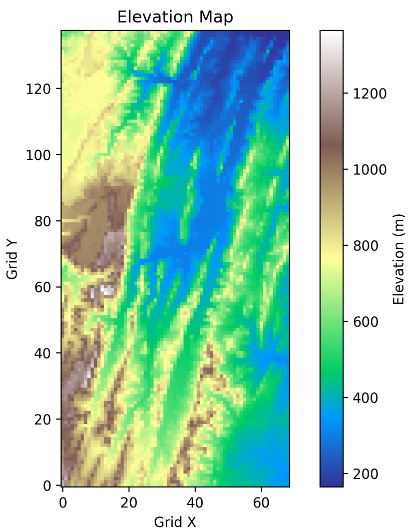
Figure 1. Manning's Roughness Distribution

Manning's Category	Manning's Value	Land Type	Proportion (%)
M0	5.56e-06	Urban and built-up lands	0.6
M1	8.33e-06	Stream order 5	0.03
M2	9.72e-06	Cropland / natural vegetation mosaics	1.49
M3	1.39e-05	Shrublands	0.06
M4	1.53e-05	Savannas	11.06
M5	1.67e-05	Stream order 3	1.32
M6	1.94e-05	Stream order 2	4.18
M7	2.50e-05	Stream order 1	5.91
M8	2.78e-05	Forests	75.34

Figure 2. Manning's Categories, Values, Land Types, and Proportions

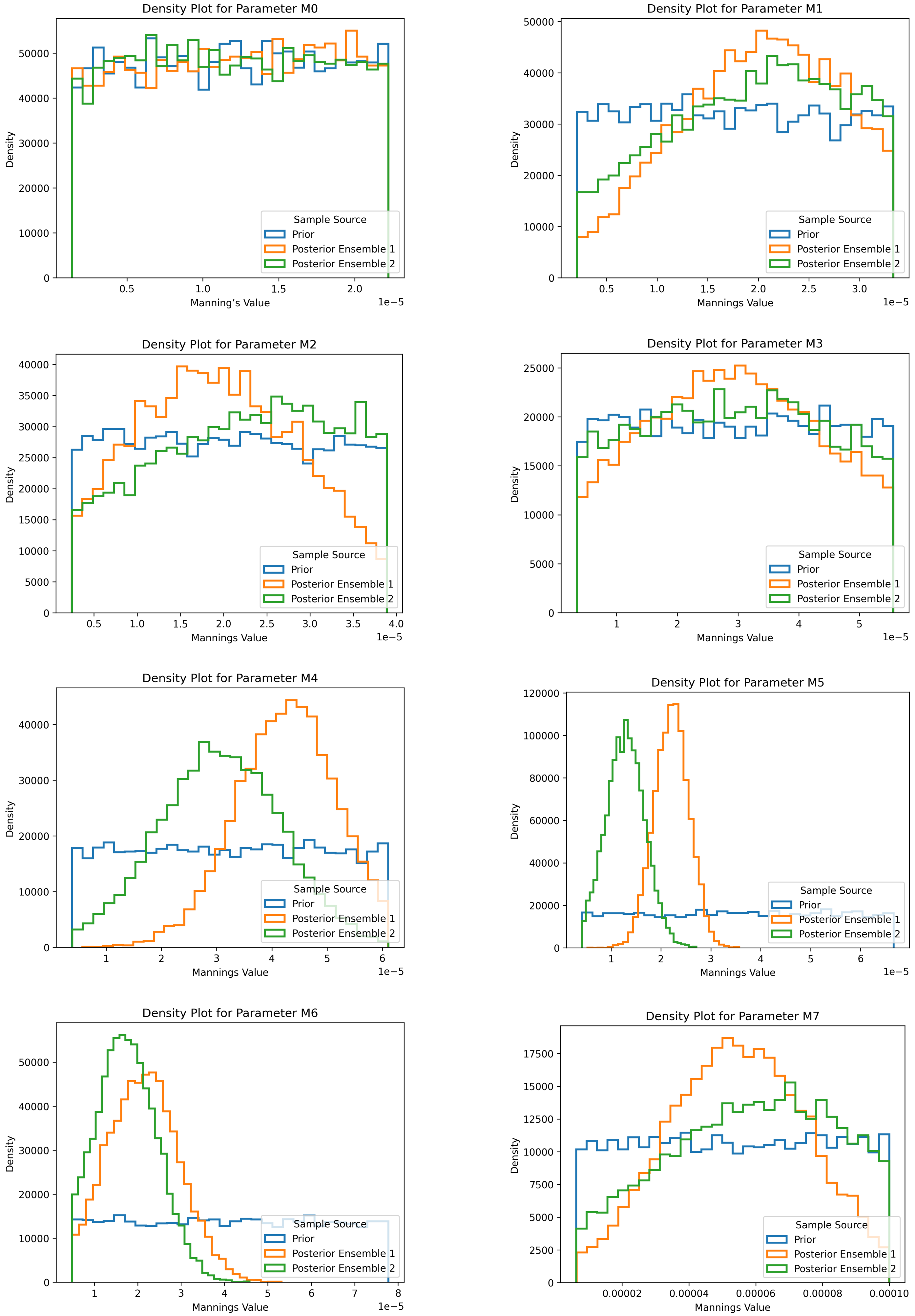
4. Elevation Mapping of HUC 02070001

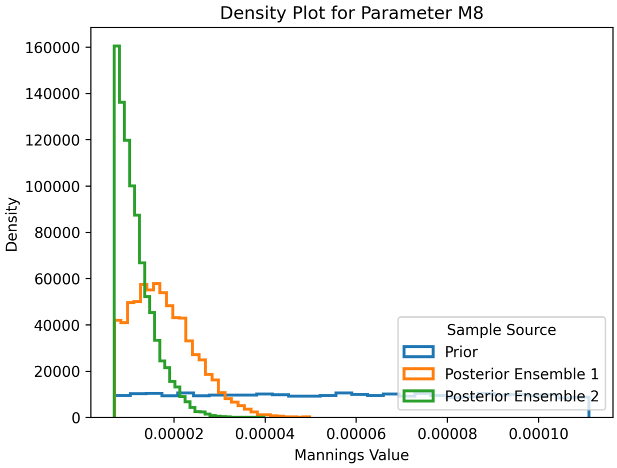
Elevation map plays a crucial role in understanding streamflow direction, as the movement of water across a watershed is influenced by terrain variations. Higher elevations serves as headwaters for many river systems, where water initially collects before flowing downstream.



5. Training SBI Following Prior Distribution Calibration

Here are the posterior density estimates obtained after calibrating the prior distribution.


Density Plot for Parameter M0
Density
Manning's Value
1e−5
Sample Source
Prior
Posterior Ensemble 1
Posterior Ensemble 2
Density Plot for Parameter M1
Mannings Value
Density Plot for Parameter M2
Density Plot for Parameter M3
Density Plot for Parameter M4
Density Plot for Parameter M5
Density Plot for Parameter M6
Density Plot for Parameter M7



6. Manning's Value with Highest Density Estimation

The Manning's value corresponding to the highest posterior density estimation was identified for both Ensemble 1 and Ensemble 2. **Table 1** summarizes the Manning's values with the highest posterior density for each category in **Ensemble 1**, while **Table 2** presents the corresponding values for **Ensemble 2**.

Table 1. Manning's Values for Ensemble 1

Manning's Category	Value
M0	1.9789e-05
M1	2.0314e-05
M2	1.76217e-05
M3	2.69077e-05
M4	4.37248e-05
M5	2.26483e-05
M6	2.088804e-05
M7	5.164242e-05
M8	1.395476e-05

Table 2. Manning's Values for Ensemble 2

Manning's Category	Value
M0	6.5963e-06
M1	2.1354e-05
M2	2.9776e-05
M3	2.5173e-05
M4	2.7710e-05
M5	1.2903e-05
M6	1.6027e-05
M7	6.4081e-05
M8	7.4502e-06

7. Visualization of Hydrograph for Ensemble 1

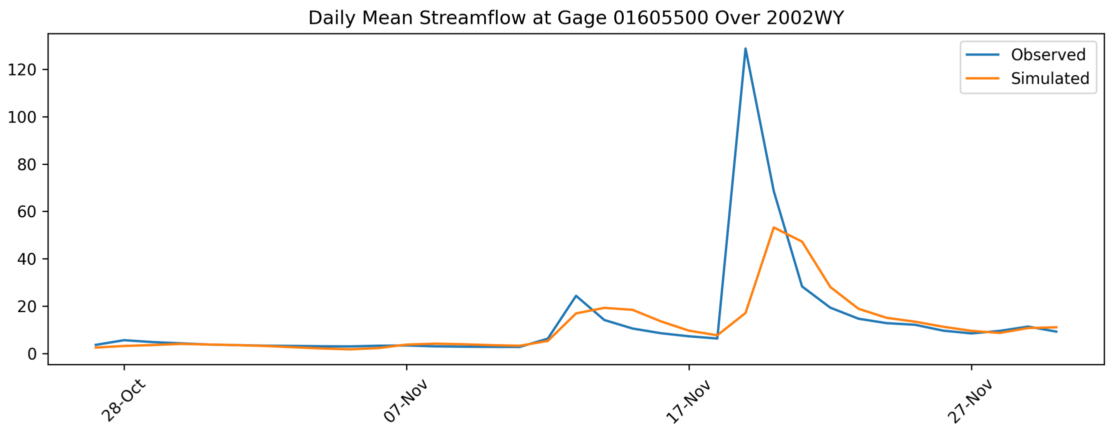


Figure 4. Daily Mean Streamflow at Gage 1 Over 2002WY

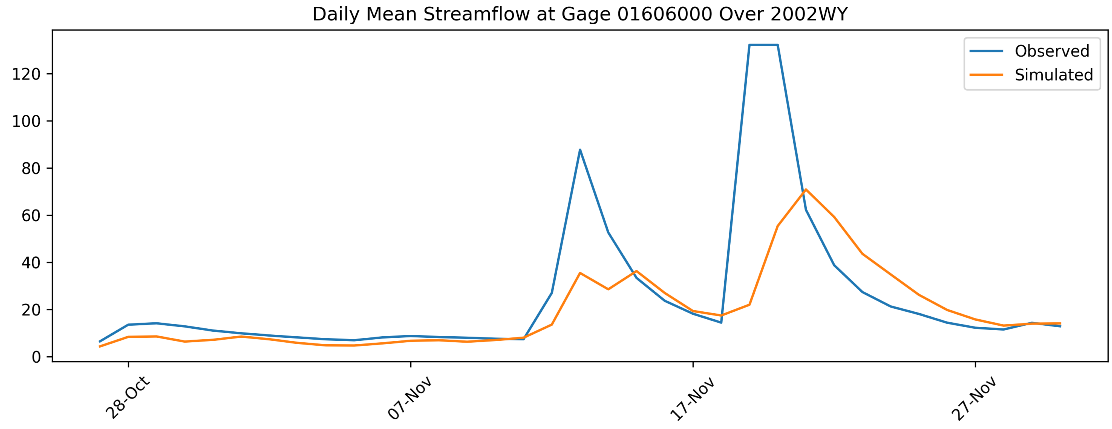


Figure 5. Daily Mean Streamflow at Gage 2 Over 2002WY

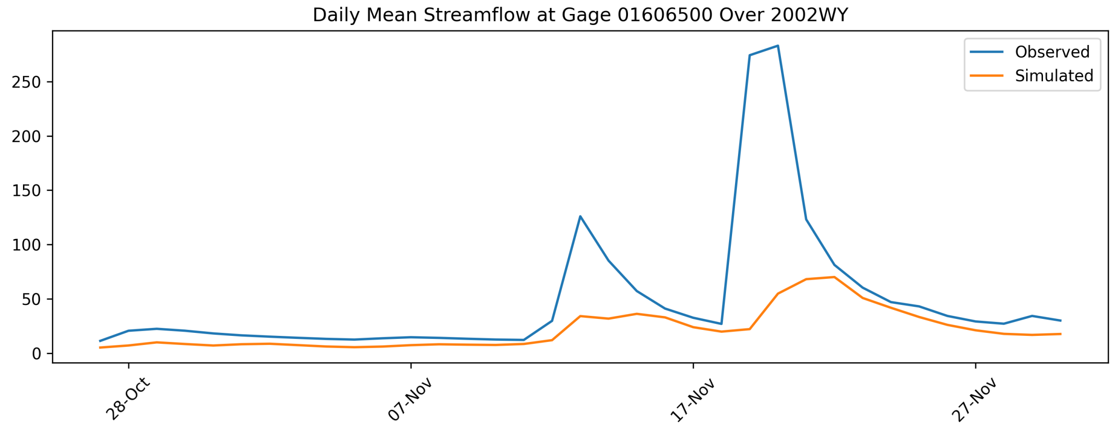


Figure 6. Daily Mean Streamflow at Gage 3 Over 2002WY

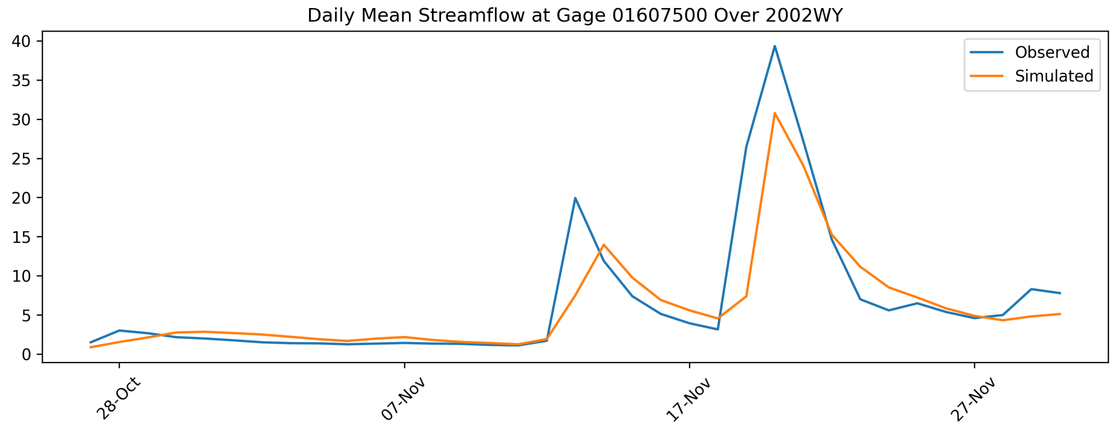


Figure 7. Daily Mean Streamflow at Gage 4 Over 2002WY

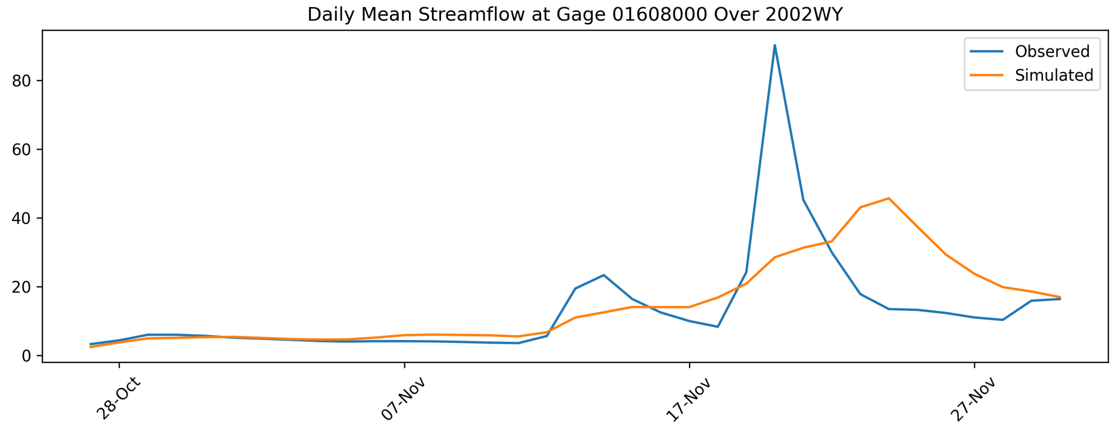


Figure 8. Daily Mean Streamflow at Gage 5 Over 2002WY

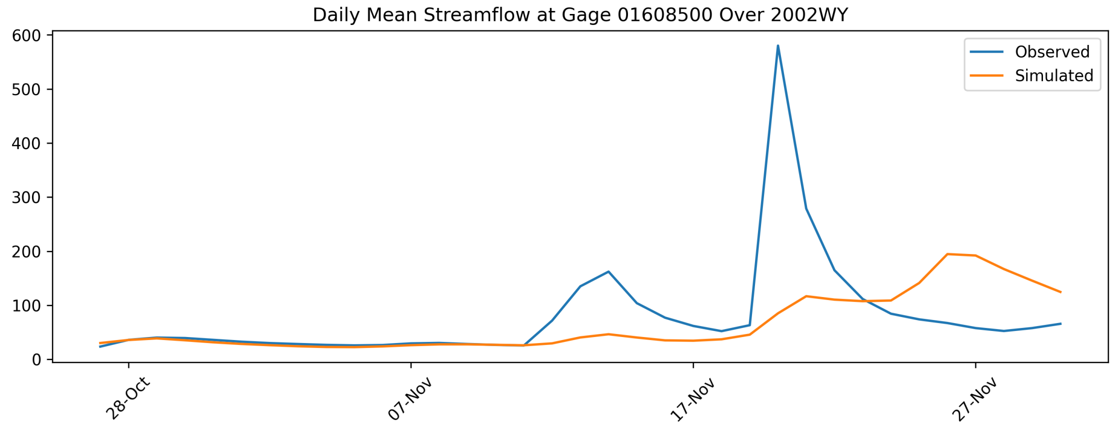


Figure 9. Daily Mean Streamflow at Gage 6 Over 2002WY

8. Visualization of Hydrograph for Ensemble 2

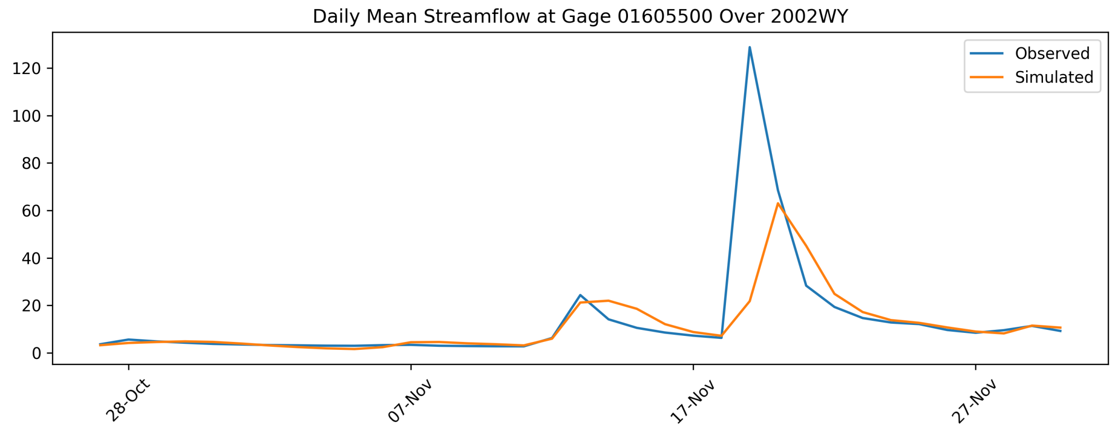


Figure 10. Daily Mean Streamflow at Gage 1 (Ensemble 2)

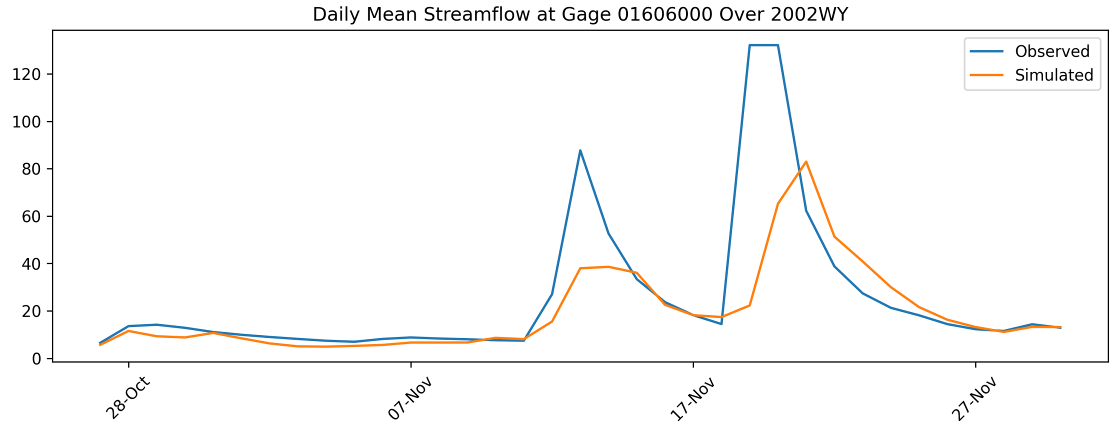


Figure 11. Daily Mean Streamflow at Gage 2 (Ensemble 2)

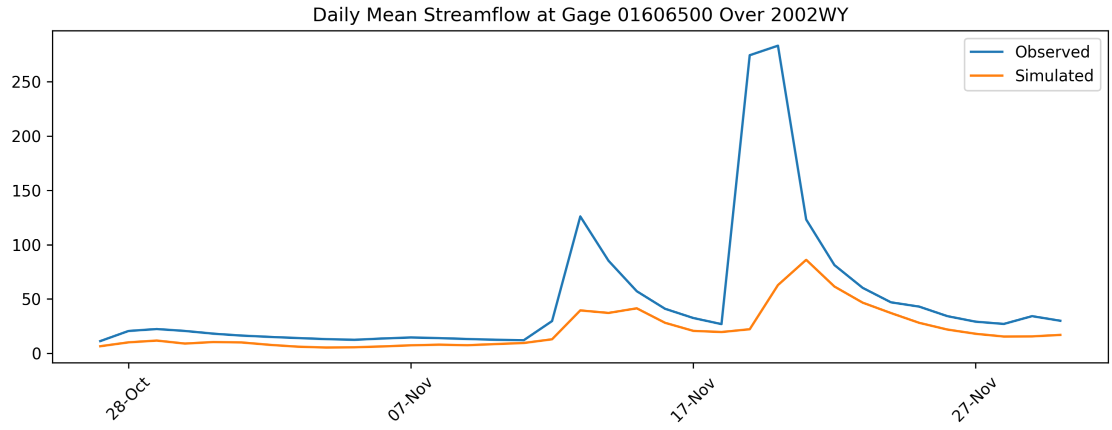


Figure 12. Daily Mean Streamflow at Gage 3 (Ensemble 2)

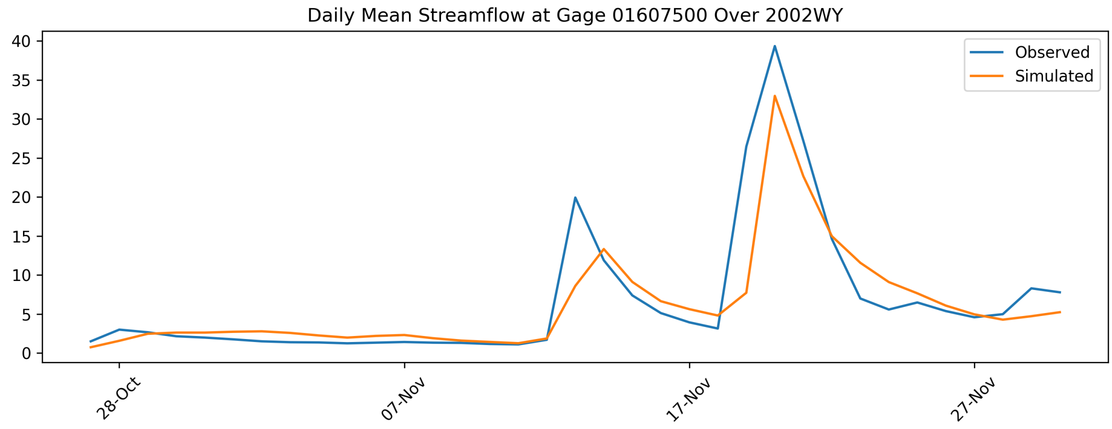


Figure 13. Daily Mean Streamflow at Gage 4 (Ensemble 2)

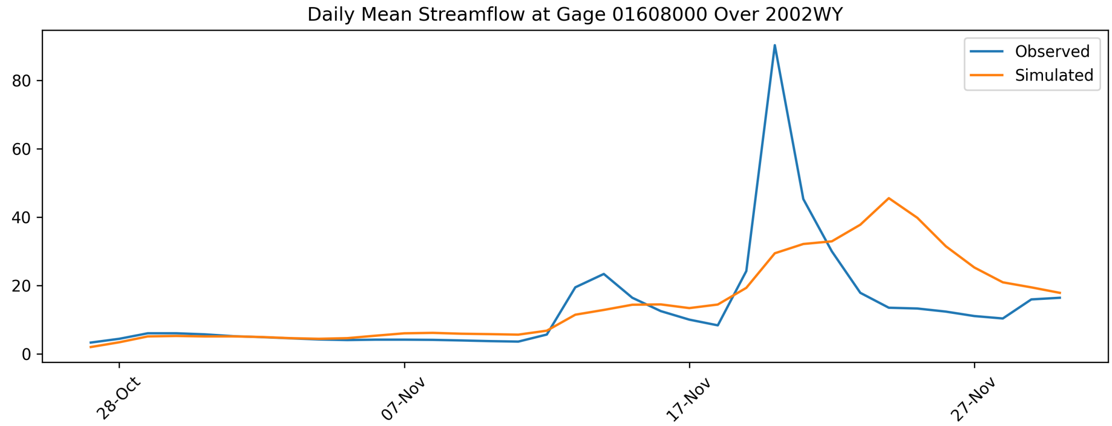


Figure 14. Daily Mean Streamflow at Gage 5 (Ensemble 2)

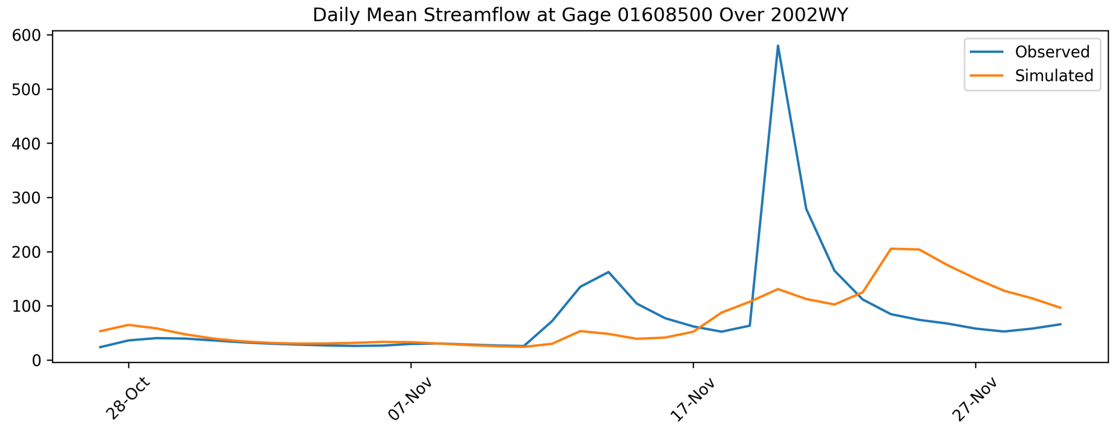
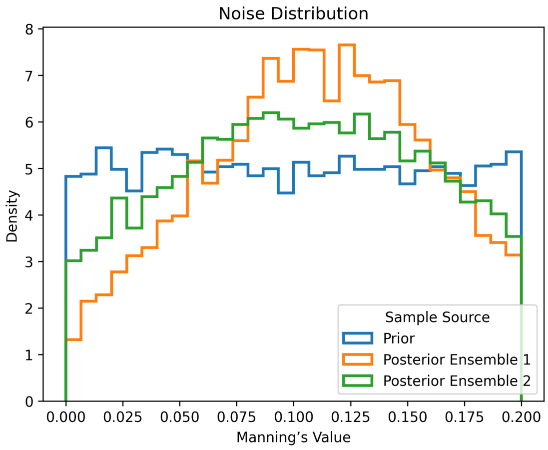


Figure 15. Daily Mean Streamflow at Gage 6 (Ensemble 2)

9. Noise Distribution for Ensemble 1 and Ensemble 2



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10. Understanding Manning's Value and Its Unit

Manning's equation, which is used to calculate streamflow velocity in an open channel, is given by:

$$V = \frac{1}{n} R^{2/3} S^{1/2} \tag{1}$$

where:

- V is the velocity of flow, measured in m/s.

- Q is the streamflow (discharge), measured in m^3/s.
- n is the Manning's roughness coefficient (unit derived below).
- R is the hydraulic radius, measured in m.
- S is the slope (dimensionless).

Rearranging for n:

$$n = \frac{R^{2/3}S^{1/2}}{V} \tag{2}$$

From the above equation, we derive the **unit of Manning's value**:

$$n = \frac{\mathrm{m}^{2/3} \cdot (\mathrm{dimensionless})^{1/2}}{\mathrm{m/s}} = \frac{\mathrm{m}^{2/3}}{\mathrm{m/s}} = \mathrm{s/m}^{1/3} \tag{3}$$

Thus, the unit of Manning's roughness coefficient is:

$$\boxed{\mathrm{s/m}^{1/3}}$$

11. Tasks and Next Steps

- Analyzing all the results
- Visualize the river flow
- Summarize my discussion with Dr. Peter Melchior.
- Construct and present the joint distribution
- Editing the code for comparing simulated data with ParFlow outputs, ensuring it is well-structured to be used by others
- Create a README file and document the analysis process for plotting.
- Continue reviewing literature related to cost-aware simulation-based inference.