Flow Regimes of the Amazon

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Overview

Ecologically relevant **flow metrics** and **annual streamflow** patterns are used to partition rivers into distinct classes, highlighting important characteristics such as **magnitude, seasonality, and flashiness** that drive biophysical processes and ecological function across the Amazon.

1. OBJECTIVES

- Develop ecologically relevant flow classifications at the basin scale

Principles of Natural Flow Regimes:

1. Channel geomorphology influences biotic diversity
2. Life history patterns
3. Aquatic Connectivity
4. Natural Regime Discourages Invasions

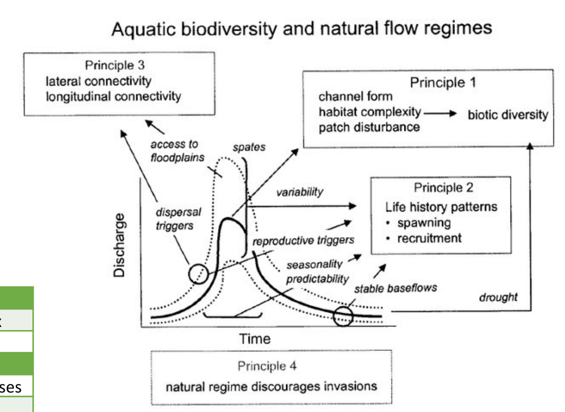


Figure 1.1: Principles of Natural Flow Regimes (Bunn & Arthington 2002)

Table 1: Indicators of Hydrologic Alteration (IHA)

Monthly Magnitude	Duration	Timing
M1: January	D1: 1-day min	T1: Date of max
M2: February	D2: 3-day min	T2: Date of min
M3: March	D3: 7-day min	**Frequency**
M4: April	D4: 30-day min	F1: # of low pulses
M5: May	D5: 90-day min	F2: Duration of low pulses
M6: June	D6: 1-day max	F3: # of high pulses
M7: July	D7: 3-day max	F4: Duration of high pulses
M8: August	D8: 7-day max	**Rate of Change**
M9: September	D9: 30-day max	R1: Rise rate
M10: October	D10: 90-day max	R2: Fall rate
M11: November	D11: Number of zero flow days	R3: Number of hydrologic reversals
M12: December	D12: Base flow index	

- Characterize patterns of variation in natural flow regimes to capture unique and shared streamflow characteristics relevant to riverine ecology
- Compare resulting classifications to the Hydrologic Global Rivers Classification

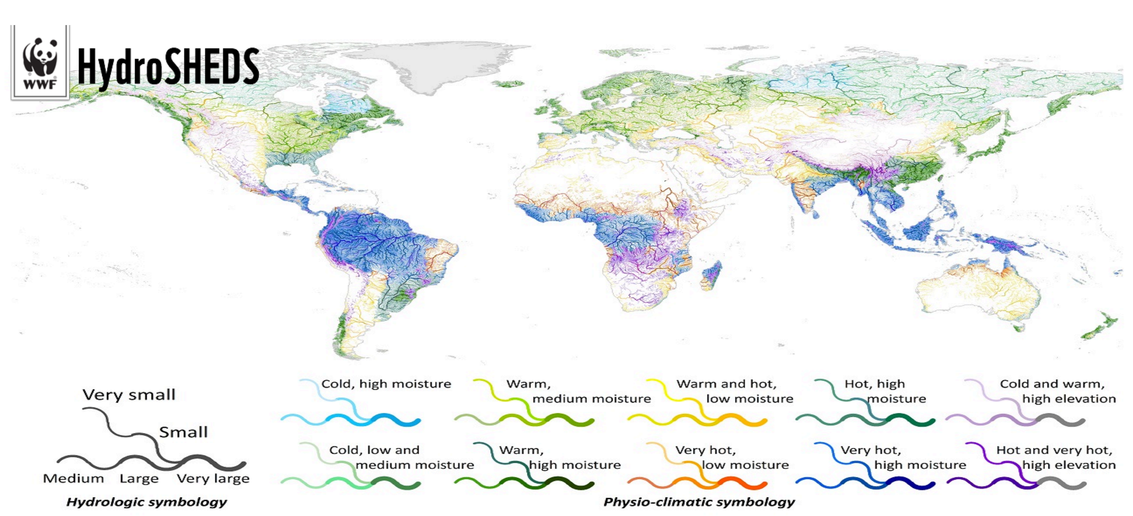
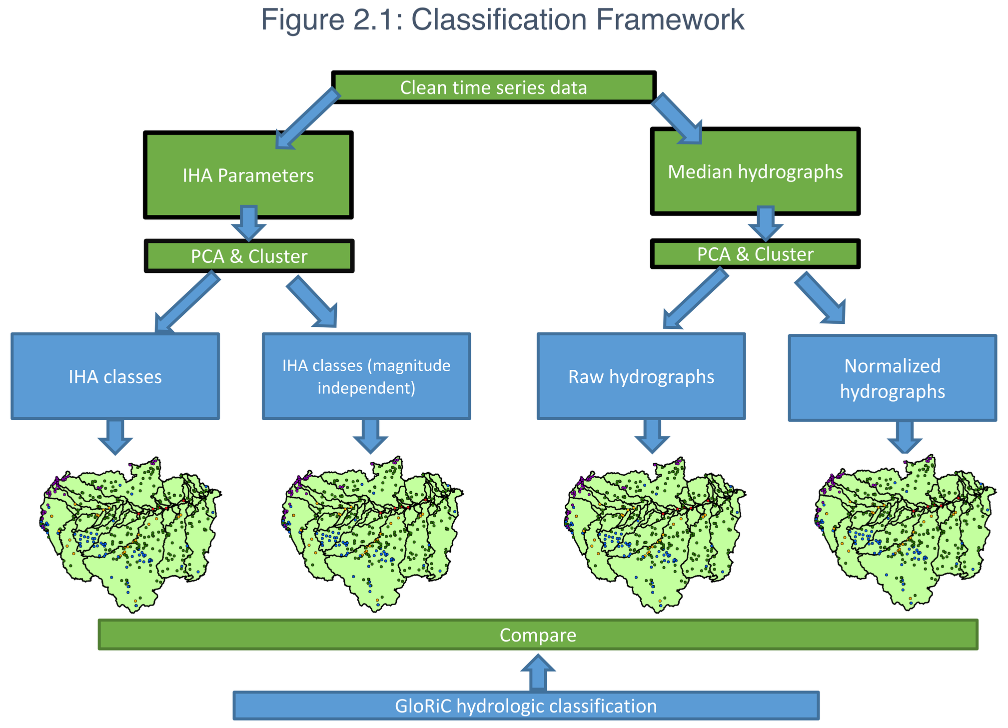


Figure 1.2: Global Rivers Classification (HydroSHEDS 2019)

2. METHODOLOGY

Figure 2.1: Classification Framework



2. METHODOLOGY

1. Streamflow data acquisition and preparation

- Download available discharge data
- Removing stations with less than 3 years of data & ≥ 80% data/year
- Interpolation of missing data
- Remove potentially dam influenced stations

Data Sources

HyBAm · IDEAM · INAMHI · ANA

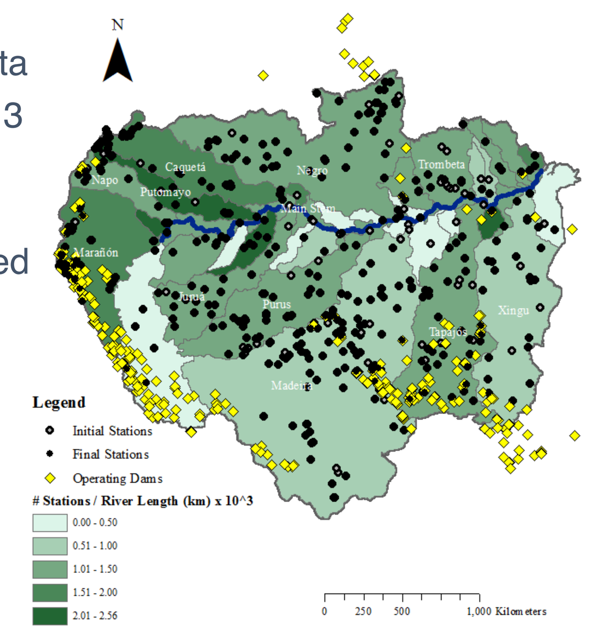


Figure 2.2: Initial and final streamflow stations included in analysis

2. Flow Metrics and Hydrographs

3. Classification

Method: Hierarchical Agglomerative Clustering

Similarity Metric: Ward's Minimum Variance Criterion

Optimal Number of Classes: Gap Statistic

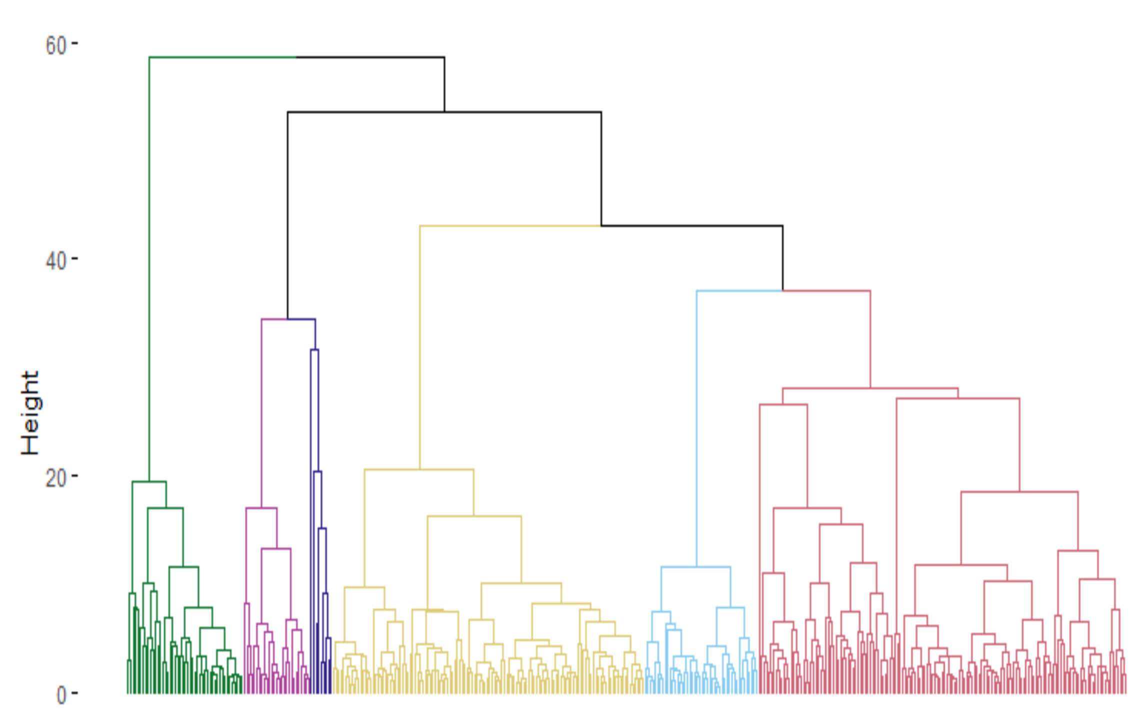


Figure 2.3: Example of hierarchical clustering dendrogram

4. Comparison to Global Rivers Classification (GloRiC)

Globally, river **magnitude** and **variability** are determined as significant hydrologic characteristics

Across the Amazon, GloRiC classes correspond to stream order and are low/medium variability

Legend

Magnitude	Variability
Very Low	Low
Low	Medium
Medium	High
High	
Very High	

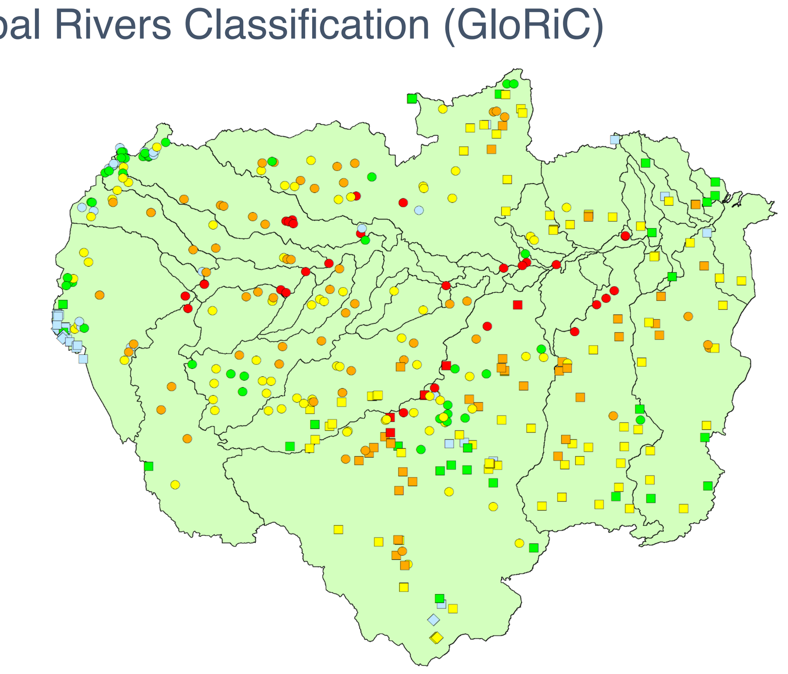
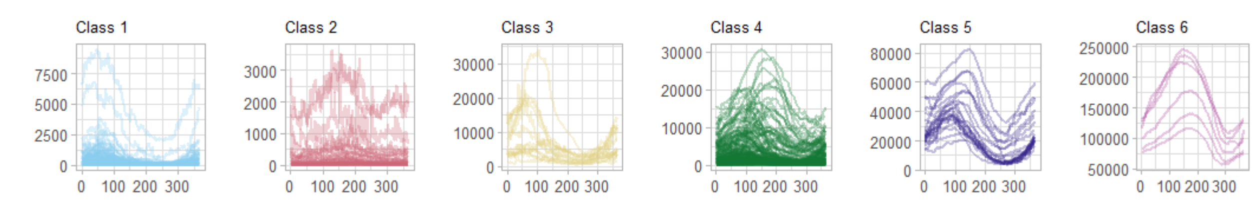
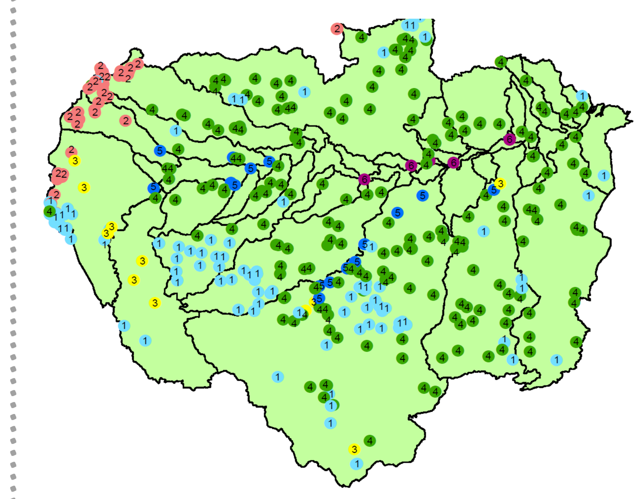


Figure 2.4: GloRiC Classifications for stations used in this analysis

3. RESULTS

Figure 3.1: **IHA: All Parameter** Classification

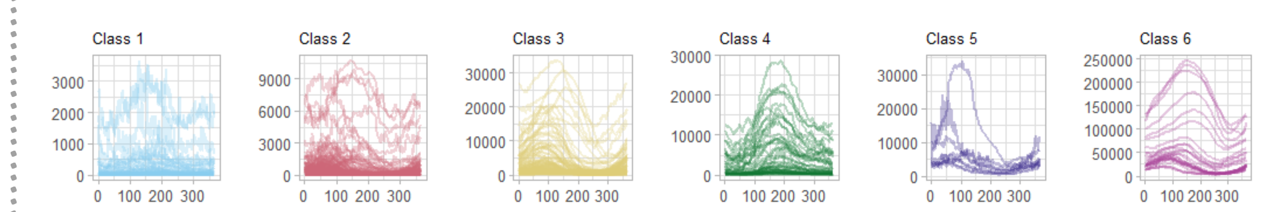


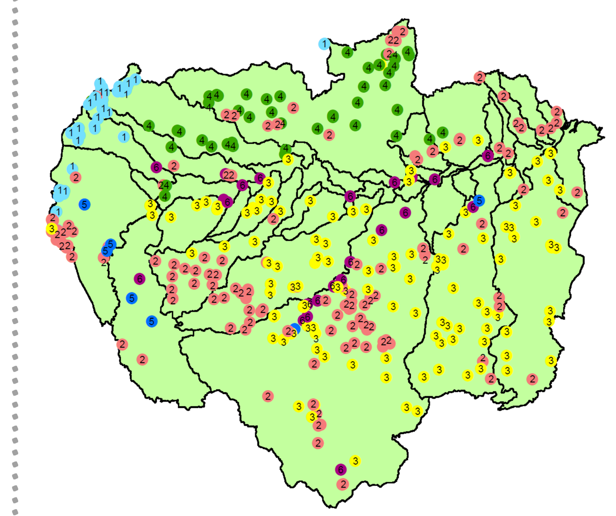


Key Attributes

- High variability in class number distribution
- Class 6 captures highest discharges
- Class 5 distributed along major tributaries
- Class 3 generally located throughout the Peruvian Amazon

Figure 3.2: **IHA: Magnitude Independent** Classification

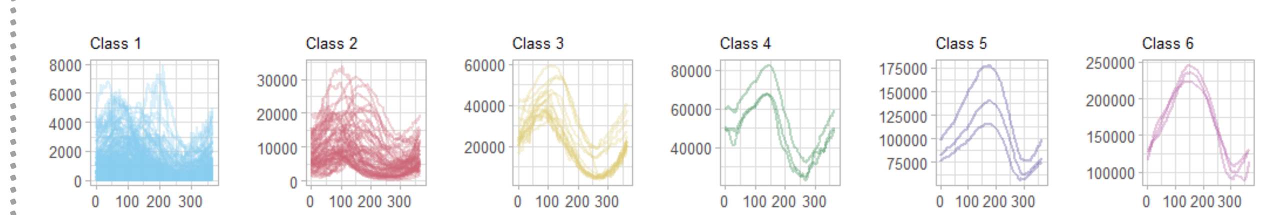


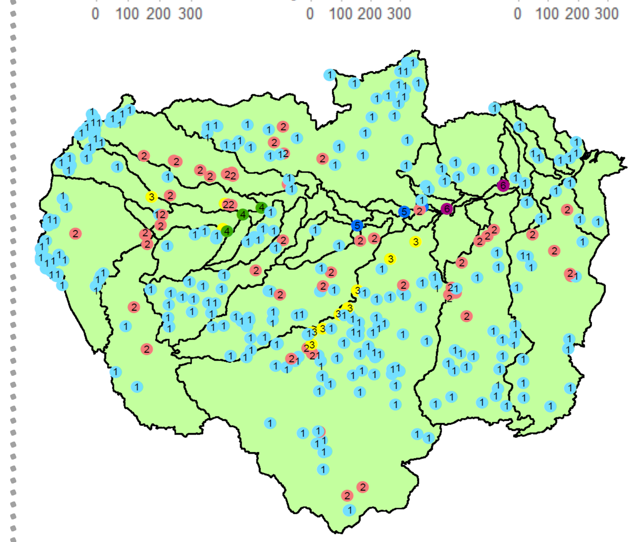


Key Attributes

- Balanced class distribution
- Class 5 have both high number of reversals and relatively large magnitude
- Class 6 distributed along Madeira River and major tributaries

Figure 3.3: **Hydrograph: Raw** Classification

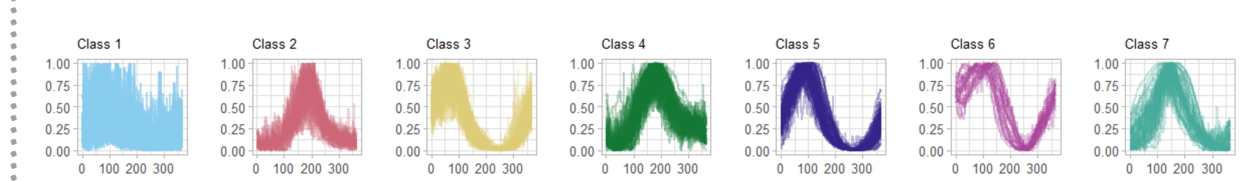


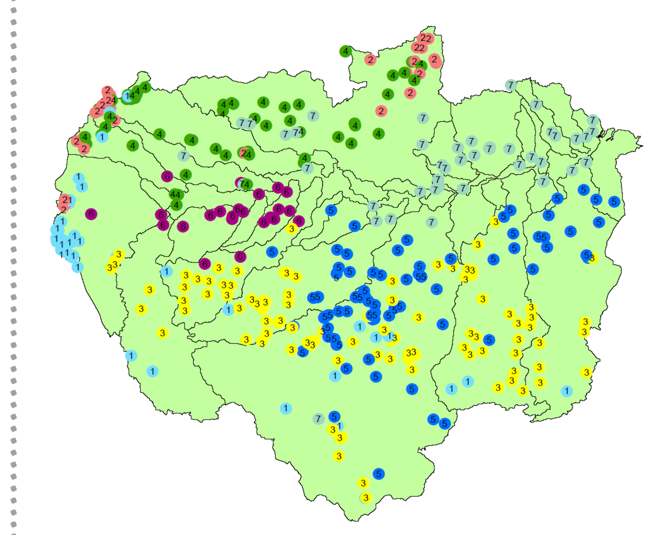


Key Attributes

- Highest variability in class number distribution
- Class 6 captures highest discharges
- Steady increase in rise rate with each class

Figure 3.4: **Hydrograph: Normalized** Classification





Key Attributes

- Most balanced class distribution
- Highest Jaccard Index values
- Generally high Normalized Cross Correlation (except Class 1)
- Class 3 and 5 overlap in range and differ in magnitude and duration parameters.

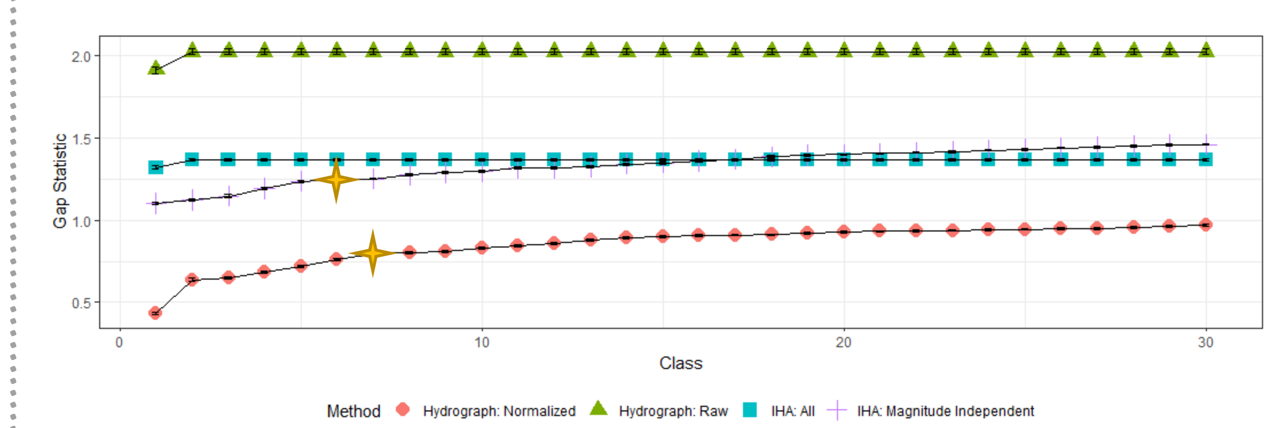


Figure 3.5: Gap Statistic Determination

4. Normalized Cross Correlation for all Methods

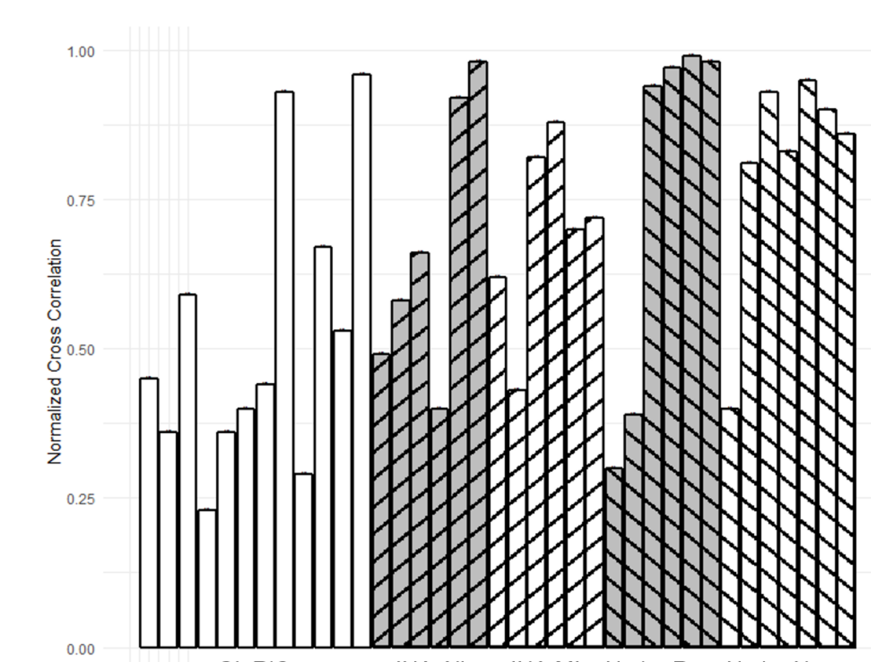


Figure 3.6: Normalized Cross Correlation

5. CONCLUSION

- Input **dataset selection** and **inclusion of magnitude** strongly control resulting streamflow classifications
- **GloRiC classes generally aligned with magnitude of classes** developed here, and exhibited similar normalized cross correlations
- **Rise rate, high pulse count, number of reversals, and seasonality (timing)** are strong drivers of flow classification

6. ACKNOWLEDGEMENTS & REFERENCES

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