Master's Thesis – Two Page Summary

Title

Hydrological Basin Classification Using Mean Annual Flow Duration Curves (MA-FDCs): A CAMELS-US Dataset Analysis

Programme

MSc in Design of River Basin Structure – University of Bologna

Student

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1. Background and Motivation

Understanding river flow regimes is essential for flood risk assessment, basin comparison, and hydrological regionalization, particularly in data-scarce regions. Flow Duration Curves (FDCs) provide a compact representation of flow variability and extremes. This thesis applies Mean Annual Flow Duration Curves (MA-FDCs) to characterize and classify river basins based on their hydrological behavior, with relevance to flood risk analysis.

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2. Objectives

The main objectives of this thesis are to:

- Construct empirical Mean Annual Flow Duration Curves (MA-FDCs) from long-term daily streamflow records
- Extract hydrological signatures describing flow regime characteristics
- Classify river basins using statistical clustering techniques
- Explore adimensionalised MA-FDCs to enable scale-independent basin comparison
- Assess the relevance of MA-FDC-based classification for flood-related hydrological analysis

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3. Data and Methods

Dataset: CAMELS-US large-sample hydrological dataset

Data selection: Catchments with at least 20 complete hydrological years (365 days)

MA-FDC construction: Empirical exceedance probability estimation from annual FDCs

Hydrological signatures extracted:

- FDC slope
- Concavity index
- Flow quantiles (Q10, Q50, Q90)

Adimensionalisation:

- Q/Qmean

- Q/Qmedian

Statistical analysis:

- Basin clustering using multivariate techniques
- Principal Component Analysis (PCA) for dimensionality reduction

Visualization:

- MA-FDC plots
- PCA scatter plots
- Spatial distribution of basin clusters

Tools: R (time-series analysis, clustering, PCA, visualization)

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4. Key Outcomes and Relevance to Flood Risk Management

The analysis highlights clear differences in flow regime behavior across basins, particularly in high-flow and low-flow conditions relevant to flood and drought processes. MA-FDC-based signatures provide a robust framework for basin classification and support comparative hydrology and regionalization. The approach is especially useful for flood risk applications in ungauged or data-scarce regions, where transferring hydrological knowledge between similar basins is critical.

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5. Relevance to Future Studies

The methodology and findings of this thesis directly support flood hazard assessment, basin similarity analysis, and model transferability, making them highly relevant to advanced studies in Flood Risk Management.