7-2024

Quantifying and Classifying Streamflow Ensembles Using a Broad Range of Metrics for an Evidence-Based Analysis: Colorado River Case Study

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RESEARCH BRIEF
from the **Utah Water Research Laboratory**

Quantifying and Classifying Streamflow Ensembles Using a Broad Range of Metrics for an Evidence-Based Analysis: Colorado River Case Study

Issued
JULY 2024

Audiences
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Key Points

- *An ensemble is a set of time series produced using a single method for water resources systems planning*
- *Streamflow ensembles are crucial for assessing water management strategies by testing the resilience of policies against potential future scenarios*
- *Historical records alone are insufficient due to climate change; the future will not look exactly like the past*
- *This study assembles a comprehensive set of metrics to statistically characterize streamflow ensembles, aiding in better decision-making*
- *Classifying ensembles based on their statistical characteristics can help identify which are most suitable for different future scenarios*



Research Summary: Using the Colorado River Basin as a case study, this research article highlights the need for streamflow ensembles that accurately represent potential future conditions rather than solely relying on historical data. The comprehensive set of statistical metrics introduced can be used to evaluate and classify these streamflow ensembles. This evidence-based framework can inform water resource management in the face of uncertain conditions.

Why this research?

Long-term planning for water supply requires assessment of multiple potential future streamflow scenarios, including current and future drought situations. Using hydrologic modeling and historical data, alternative policies and management strategies are assessed for performance in future scenarios.

But with climate change and growing recognition that hydrologic processes are changing over time, the past may no longer be representative of the future. This poses challenges when using statistical metrics to test potential future streamflow time series. This paper presents an evidence-based approach for analyzing and characterizing future streamflow using an extensive set of statistical metrics.

What we did

The Colorado River Basin was chosen as the case study due to significant challenges in increased water demand and the need for innovative strategies to adapt to evolving conditions. A broad set of statistical metrics was assembled and applied to categorize annual streamflow in the Colorado River at Lees Ferry.

The metrics presented, alongside their systematic classification, provide an analytical framework for characterizing and assessing the suitability of future streamflow time series for water resources system planning. They provide information to help make decisions on which streamflow scenarios should be used for planning purposes. The comprehensive set of metrics provided addresses the limitations of reliance on just a few statistics.

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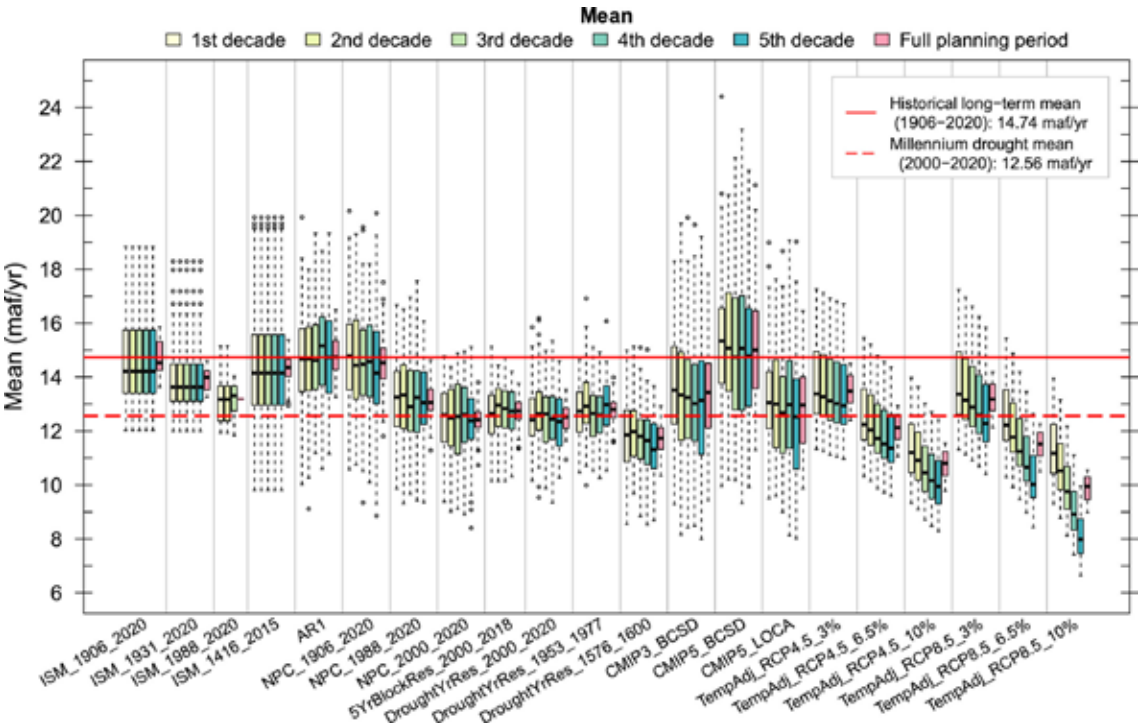
Read More: *Salehabadi, H., Tarboton, D. G., Wheeler, K. G., Smith, R., & Baker, S. (2024). Quantifying and classifying streamflow ensembles using a broad range of metrics for an evidence-based analysis: Colorado River case study. Water Resources Research, 60, e2024WR037225. https://doi.org/10.1029/2024WR037225*



Mean of streamflow ensembles along with the long-term mean of the historical full record (1906-2020, solid red line) and the millennium drought mean (2000-2020, dashed red line). Yellow to green boxes of each ensemble show decadal mean and the pink boxes indicates the mean of the full planning period.

The metrics were used in the case study for three purposes:

- To provide a quantitative description of each individual ensemble
- To conduct comparisons among ensembles
- To classify ensembles based on their characteristics

What we found

The sidebar to the right lists the statistical metrics used in the case study. The figure above details the time series in the case study, showing how some time series represent a declining trend while others are stationary or represent a downward shift.

The ranges of decadal mean (yellow to green boxes) and full 50-year period mean (pink boxes) of the 21 ensembles evaluated show how dry or wet the time series evaluated are, compared with each other and the historical long-term mean of 14.74 maf/yr (solid red line). Decadal means show how the mean changes over shorter time spans during the planning period and informs understanding on the characteristics of streamflow over decades.

Why it matters

This study provides an analytical framework for characterizing and assessing the suitability of future streamflow ensembles for water resources system planning, especially in large river basins dealing with uncertainty.

Understanding the occurrence, duration, and severity of hydrological droughts, as well as frequency and magnitude of surpluses, is essential for making informed decisions regarding water allocation, reservoir management, and drought preparedness. Using these metrics to interpret the differences among ensembles will aid in decision making.

List of Metrics

- Trend
- Mean
- Median
- Minimum
- Maximum
- Standard deviation
- Skewness
- Auto correlation
- Partial autocorrelation
- Hurst coefficient
- Drought length
- Drought cumulative deficit
- Drought intensity
- Drought interarrival time
- Count below threshold
- Count above threshold
- Reservoir storage-yield and reliability
- Duration-severity analysis
- Cumulative deviation
- Mutual information

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