

# General Assessment

This manuscript presents a large-sample analysis of within-catchment spatial variability of hydrological droughts using a dense reconstructed streamflow dataset across cold, humid catchments in southern Québec. The study addresses an important and often overlooked assumption in hydrological drought assessment—namely, that drought conditions are spatially coherent within a catchment and can therefore be adequately represented by a single stream gauge.

The analysis convincingly demonstrates that hydrological droughts may exhibit substantial spatial heterogeneity, and that reliance on a single monitoring location can lead to systematic underdetection of drought events. For example, the authors show that using only one downstream reach may miss on average about one-third of drought events within a catchment, highlighting important implications for drought monitoring and network design.

The manuscript is generally well structured, clearly written, and supported by a rich dataset and appropriate statistical analyses. The findings are potentially valuable for hydrological monitoring strategies and drought risk assessment. I consider the manuscript suitable for publication after **minor revisions**, mainly aimed at strengthening uncertainty discussion and improving process-based interpretation, rather than requiring additional analyses.

## Major Comments

### 1. Role of Reconstructed Streamflow Uncertainty

The study relies entirely on reconstructed streamflow products derived from hydrological modelling and data processing. Because spatial variability is a central conclusion, it is important to clarify to what extent the detected heterogeneity could be influenced by reconstruction uncertainty, model structure, or interpolation effects.

I do not suggest re-analysis, but the Discussion should explicitly address: whether reconstruction errors may artificially enhance spatial variability.

Adding such discussion would significantly improve interpretability and credibility.

### 2. Sensitivity to Drought Definition (SSI Threshold)

The manuscript already evaluates multiple SSI thresholds, showing that relationships remain generally consistent across definitions. However, because spatial coherence is inherently sensitive to drought definition, this sensitivity deserves stronger visibility in the main text rather than primarily in appendices.

I recommend briefly summarizing key sensitivity outcomes in the Results section to clarify how robust the central conclusions are across drought thresholds.

### **3. Strengthening Mechanistic Interpretation**

The Discussion proposes plausible drivers of spatial drought heterogeneity, including climate variability and local catchment processes. However, these explanations remain largely conceptual.

Without requiring additional modelling, the manuscript could be strengthened by: more explicitly linking observed spatial patterns to known hydrological processes in cold, humid environments (e.g., snowmelt dynamics, storage buffering, groundwater contributions), or clarifying which mechanisms are supported by evidence versus proposed as hypotheses.

This would enhance the broader scientific contribution beyond empirical characterization.

### **Minor Comments**

- Please clarify the rationale for selecting SSI over alternative hydrological drought indicators.
- Provide a short justification for using drought severity (rather than duration) in the mixed-effects modelling framework.
- Discuss more explicitly the transferability of conclusions beyond cold humid regions.
- Statements regarding implications for monitoring network design may be slightly overstated and should be framed with appropriate caution and context.