

Review for: Quantifying within-catchment spatial variability of hydrological droughts in cold, humid regions

General comments

The manuscript addresses an important and understudied question using a valuable long-term streamflow reconstruction across 109 catchments and 6,718 reaches. The overall framework is relevant, and the analyses across multiple SSI thresholds, accumulation periods, and monitoring densities provide a useful basis for assessing within-catchment drought variability.

However, several conceptual and methodological issues need to be resolved before the principal conclusions can be considered robust. Most importantly, spatial coherence is defined in terms of simultaneous drought occurrence, whereas the principal spatial metric represents the cumulative proportion of the stream network affected at any point during a grouped event. The event-grouping procedure and statistical model formulation also require clarification, particularly because they may influence the reported relationships among drought extent, duration, and severity. The manuscript would benefit from a clearer distinction between cumulative spatial extent and simultaneous spatial coherence, together with appropriate revision of the analyses and interpretation.

The Discussion would benefit from more process-based interpretation of the results. In particular, please explain the hydrological mechanisms that may cause droughts to remain localized or become widespread within a catchment, and how factors such as climate variability, tributary differences, and flow regulation may influence the observed patterns.

Specific comments

1. Abstract, lines 15-20: The reported values of 37% widespread and 14% localized events apply specifically to $SSI < -1.5$ and change considerably with the selected threshold. Please state this threshold explicitly in the abstract and highlights. Also, is there any information about how these missed drought events vary as a function of catchment size that could be included in the abstract? The abstract also states that approximately 30% of drought events would be missed by a downstream gauge, whereas the Results report 37% when all events are considered; the 30% value applies only after single-reach events are excluded. Please clarify this distinction.
2. Abstract should also be more explicit about the spatial domain of the study and should clearly state that the analysis is based on a modeled streamflow dataset rather than observations at all reaches.
3. Abstract, lines 20-21: The finding that widespread droughts are also more severe is somewhat surprising, particularly because severity may be interpreted by some readers as intensity. Please clarify the distinction between drought severity and intensity and ensure that this result is adequately discussed in relation to the existing drought literature.
4. Introduction, lines 59-60, and Sections 2.4, lines 163-171: The Introduction defines spatial coherence as the simultaneous occurrence of drought across locations. However, the calculated spatial-extent metric includes all reaches affected at any point during a grouped event. It therefore represents cumulative spatial coverage or event footprint rather than simultaneous spatial coherence. Please distinguish these concepts throughout the manuscript. Either use "cumulative spatial extent" consistently or provide a time-resolved metric, such as the mean or maximum proportion of the network simultaneously experiencing drought during each month.
5. The Introduction would also benefit from more discussion of existing work on the spatial extent of other types of drought and its relationship with intensity and/or severity. This would help establish the study's contribution and provide context for interpreting the reported relationship between widespread drought and greater severity.
6. Section 2.3, lines 145-155: The best-fitting distribution is selected independently for each reach. Please justify this choice, report how often each distribution was selected, and assess whether it creates spatial inconsistencies in SSI classification. Maybe a map of which SSI distribution was selected per reach, to check whether distribution selection is spatially structured or not.
7. Section 2.4, lines 163-171: Reach-level drought events are grouped whenever they overlap by at least one month. This procedure may create transitive event chains: event A may overlap event B, and event B may overlap event C, although events A and C never occur simultaneously. Such

chaining may increase the estimated catchment-scale duration, severity, and cumulative extent. Please describe the grouping algorithm more clearly, quantify how frequently event chaining occurs, and assess sensitivity to a more restrictive event definition.

8. Section 2.5: Although the section is titled “Statistical modelling of spatial coherence,” the model uses drought severity as the response variable and spatial extent as a predictor. It therefore evaluates whether spatially extensive droughts are more severe rather than directly testing whether severe droughts are more spatially coherent. Please clarify and justify the direction of inference.
9. I recommend adding at least one spatial figure: examples of catchment maps illustrating a widespread and a localized drought event, to make the central finding visually concrete and to allow assessment of whether localized events cluster within sub-basins or appear spatially incoherent.

Technical corrections

1. Abstract Lines 9-10: This is a big claim, is it supported in the introduction? It’s hard to say “studies don’t do x” without a very clear overview of those studies. Consider alternative framing.
2. Lines 12-13: Change “one of the first large-scale assessment” to “one of the first large-scale assessments.”
3. Line 13: Change “streamflow timeseries” to “streamflow time series.”
4. Line 25: Delete the stray number “32” after “drought.”
5. Lines 141-147: Use consistent terminology. Lines 141-142 refer to the monthly streamflow time series of each “catchment,” whereas lines 146-147 refer to each “stream reach.” Replace “catchment” with “stream reach” if this reflects the analysis.
6. Line 155: Reconcile the publication year of Gudmundsson and Stagge. The text cites 2014, whereas the reference list gives 2016.
7. Line 161: Change “McKee et al., (1993)” to “McKee et al. (1993).”
8. Line 197: Change “the number of stream gauges ... require to detect” to “the number of stream gauges ... required to detect.”
9. Line 216: Change “experienced droughts conditions” to “experienced drought conditions.”
10. Line 226: Delete the duplicated period after “Table 2.”
11. Lines 241-242: Change “reaches not experienced drought conditions” to “reaches not experiencing drought conditions.”
12. Line 288: Replace the reference to “Fig. 3” with “Fig. 5.”
13. Line 368: Correct “corelate” to “correlate.”
14. Line 421: Change “contains incorporates uncertainty” to either “contains uncertainty” or “incorporates uncertainty.”
15. Table A1 caption: Change “fall = September/October/December” to “fall = September/October/November.”
16. Use “time series” rather than “timeseries” throughout the manuscript.
17. Use consistent capitalization for “Figure,” “Table,” and section references throughout.