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Comment

Interactive comment on “Technical Note: Characterizing hydrologic change through catchment classification” by K. A. Sawicz et al.

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Received and published: 13 June 2013

Overview

The authors classify several hundred USA catchments according to hydrological signatures in the decade 1948–58, and then examine how that classification changes in succeeding decades. The authors' idea of testing whether hydrological classifications can be used to analyse hydrological change with time is new (at least to me) and worthwhile. However, there were a number of points where clarification is needed, and these are detailed below.

Each comment begins with the page number and line number to which it refers.

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Main points

1. 6601L24-25 “Climate change will increasingly create . . .” and all following text to the end of the paragraph. The sentences do not flow logically; I think the whole paragraph needs rewriting.
2. 6603L14 “For a more detailed discussion of these signatures see Sawicz et al. (2011).” Only 4 of the 6 signatures used here were also in Sawicz et al 2011, who provided some justification for the selection of signatures: “largely uncorrelated and that have an interpretable link to catchment function”. Why did the authors change two of the signatures? What is the justification for including Q10 and Q90, and omitting streamflow elasticity and rising limb density?
3. 6603L15 “The signatures used here are . . .” One of the Sawicz et al 2011 criteria for signature selection was that signatures be largely uncorrelated. Is there redundancy in using the slope of the FDC, and also Q10 and Q90 (whose difference will correlate with slope of FDC)? Or in using both BFI and Q90 (which are likely to be correlated)? Why is Q90 in mm units, but Q10 in dimensionless units?
4. 6604L1 “Ratio of snow days” I think it would be more hydrologically relevant to use the ratio of average annual snowfall (calculated using precipitation and a temperature threshold) to average annual total precipitation.
5. 6606L11-15 “A more widely spread cluster of catchments is found along the south-east coast of the US and is characterized by the permeable geology of this region, exhibiting therefore flat flow duration curves (FDC) and relatively high baseflows (Group 2) (Bloomfield et al., 2009). These catchments experience storms of short duration with dry summers resulting in significant low flow periods.” These two sentences seem inconsistent with one another. Can a region simultaneously have flat flow duration curves with high baseflows, and also have low summer flows?
6. 6607 and Figure 3 caption: “CART decision tree showing what physical and climatic

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characteristics control the classification". I found this statement misleading in two respects. First, because the CART tree shows how signature values control the classification, rather than how physical and climatic characteristics control the classification. Second, because the CART tree effectively is the classification, albeit summarised and simplified a little. The inputs to the CART tree were the inputs to the Autoclass classification, and the outputs of the CART tree are the classes produced by the Autoclass classification. The purpose of the CART analysis is unclear – is it intended to convert a black box classification process into a white box?

7. 6608L18 "With the exception of the catchments in the western US, which experience a dramatically different distribution of precipitation" This complexity might be avoided if the authors used fraction of annual precipitation that falls as snow, rather than ratio of snow days.

8. 6609L8 to end of paragraph "We briefly discuss the potential impact of both climate and land use change on hydrologic signatures" I found much of the material in this paragraph quite speculative; it needs tightening up or removing. While some specific comments are present in the paragraph, the entire paragraph needs critical review to identify unsupported assertions, vague statements of impact ("can allow more water", "might occur"), and statements of impact which do not specify the direction of anticipated change ("altering the distribution of", "Changes to SFDC are influenced by").

9. 6609L12 "These changes altered catchment behavior by impacting precipitation patterns" Such effects have been recognised for tropical deforestation and subsequent conversion to agriculture in eastern Amazonia and West Africa, but I am not aware of similar results for anywhere in North America, so a relevant citation is needed to support this statement.

10. 6609L14 "Logging for example can allow more water to be stored in the soil while simultaneously decreasing the amount of water leaving a catchment through evapotranspiration, therefore impacting runoff ratio (Woodbury et al., 2006)." I found this

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statement very unclear. I don't see how the Woodbury paper is relevant, since it does not address the effects of changes in land cover on any aspect of the water cycle. It is not clear whether the authors mean to say logging (where forest may be followed by either another forest, or by a new land cover) or deforestation. My understanding is that the main long-term hydrological effect of changing land cover from forest to short vegetation is typically a decrease in evaporation and an increase in runoff. The precise mechanisms by which these changes take place depend on the context; for some climates and tree species the change is mainly through a reduction in the interception of rainfall, but in other settings it is mainly through reduced transpiration (though there are numerous other consequential changes to water flow pathways).

11. 6609L16 "Changes in agricultural extent will impact catchment behaviour . . ." and also L19 "Increasing agricultural activity likely increases evapotranspiration" What was the land use or land cover before agriculture? Is the agriculture irrigated? If yes, is the water source for irrigation from within the catchment, or is it "imported" water via a canal or from regional groundwater?

12. 6609L16 "by altering partitioning at the land surface (for example changing SFDC) or by altering the distribution of quick versus slow flow paths (BFI)." What is the difference between "partitioning" and "distribution of quick versus slow flow paths"? If partitioning refers to evaporation vs runoff, then surely RQP is more affected than SFDC? Why did the authors choose to use SFDC as the example for partitioning?

13. 6611L9 "We identify groups of catchments that change class assignment between decades" Given the arbitrary and sharp nature of the class divisions, we would expect some random changes in class membership between decades, because of sampling variability. Can the authors quantify the uncertainty in class membership? If hydrology was stationary, how many catchments are expected to change class each decade because of sampling variability?

14. The authors do not cite much literature on the previously-identified decadal-scale

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changes in the hydrology of the USA. For example, I would have expected to work of Dettinger, Cayan etc on changes in winter and spring hydrology (streamflow amount and timing) in the western USA to be mentioned in relation to the change in number of snow days and its effect. Similarly the work of Bosch and Hewlett and others more recently, in relation to impacts of forest-related land use changes. Also, the papers by McCabe and Wolock (1997) or Lins and Slack (1999), which had the same US-wide examination of trends in streamflow. There are also numerous region-specific papers which are relevant (e.g. Garbrecht et al 2004 on changes in Great Plains streamflow).

15. 6614L26 “no general trends were found that suggested agriculture had an effect on RQP.” This statement would be more useful if the authors also provided information on the land use before agriculture (was the new agricultural land previously forested, or was it being used for a less intensive form of agriculture?). This should then be followed up with a discussion citing the relevant literature where such trends had been detected by other studies.

Minor points

16. 6600L9 “This activity allows us to assess . . .”. I would say something like “This analysis allows us to assess . . .”

17. 6600L11 “We found situations where catchments belonging to one class would diverge into multiple classes, and conversely cases where catchments from different classes would converge into a single one.” I would rewrite with explicit mention of decades, rather than use of diverge/converge

18. 6603L14 Sawicz et al 2011 is missing from the list of references.

19. 6600L23 “has seen steep rise in interest in recent years suggesting that there is significant interest” Rephrase to avoid using “interest” twice in one sentence. Insert “a” between “seen” and “steep”.

20. 6601L4 “Tracers provide more insight, but are not widely available” I would say it is

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the data which are not available, rather than the tracers themselves.

21. 6601L18 “As the topic of catchment classification is increasing in interest, there is the recognition of the increasing nonstationarity of the hydrological cycle,” I don’t see how these two phrases are connected.

22. 6604L3 “This signature is a proxy for flow seasonality . . .” It is presumably only a limited proxy for flow seasonality, which also varies for other reasons, such as the seasonality of precipitation minus evaporation.

23. 6604L21 “The input variables characterizing the catchments, i.e., the signatures, were log transformed and modeled as normally distributed continuous variables with an associated degree of uncertainty.” How was this uncertainty quantified?

24. 6609L27 “the SFDC signature is less unaffected extreme flood and drought events.” Some words seem to be missing from this phrase

25. 6610L21 “(most extreme center of mass value of -4% between periods 1 and 2)” Which centre of mass is referred to here? How can a centre of mass be a negative percentage?

26. 6612L10 “Initially, the primary catchments that split into classes C0, C3, C4, and C5 because of to differences in values of SFDC, BFI, and RSD.” This sentence doesn’t make grammatical sense.

27. 6612L12 “The energy-limited catchments are further separated from the water-limited catchments in C1 (dark green) during the baseline period.” I couldn’t interpret this sentence. Which classes are being referred to as energy limited? Along which axis is this separation taking place? With respect to which other decade or place are you saying that the separation is further? I had a similar difficulty with the first half of the following sentence.

28. 6627 “the boarder color” border, not boarder?

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References:

Garbrecht J.D., Van Liew M., Brown G.O. 2004. Trends in precipitation, streamflow, and evapotranspiration in the Great Plains of the United States. *Journal of Hydrologic Engineering* 9(5):360-367.

Lins, H., and J.R. Slack, 1999: Streamflow trends in the United States. *Geophysical Research Letters*, 26, 227-230.

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Disclosure: Two of the authors are current/former close colleagues of mine. The Editor who requested my review was aware of this relationship.

Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, 10, 6599, 2013.

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