

Hydrol. Earth Syst. Sci. Discuss., referee comment RC3  
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## Review comments

Anonymous Referee #2

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Referee comment on "Critical transitions in the hydrological system: early-warning signals and network analysis" by Xueli Yang et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-120-RC3>, 2021

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This paper focuses on critical transitions in precipitation and potential evapotranspiration (PET) both globally and in U.S. urban areas, based on monthly and annual datasets. The authors use various network and correlation measures to identify how system properties change leading up to critical transitions, which are defined as abrupt changes in behavior. They find that autocorrelation and standard deviation computed on moving time windows tend to increase before a defined critical transition point, indicating the potential use as early warning indicators. In an extension to a spatial network of precipitation in urban regions, the authors introduce network connectivity measures and similarly consider how these measures predict critical transitions in precipitation anomalies.

The paper was interesting and relevant to the journal and I think it will make a valuable contribution. The addition of a spatial network perspective on critical transitions in precipitation was particularly interesting to me. However, I have several major and minor comments on the structure of the paper and the methods as detailed below. Mainly, in the methods I would like to question the identification of a critical transition in general, and the possibility for trends in indicators without any critical transition occurring. In terms of the writing, there is a lot going on and several of the sections could be more clearly explained and tied together.

\*Note, After writing this initial review, I notice that some comments were addressed based on previous reviewer comments, but have not removed them, so they may now be redundant.

Major comments:

Writing:

The introduction would benefit from some restructuring. For example, there are 3 separate places where different "research gaps" are established, and these could be better tied together. Specifically: line 69 where "early warning signals remain obscure", line 83 where "hydrological processes remain un-explored", and line 87 "few studies have examined climate similarity". This makes it hard to follow what is actually being addressed. These could be combined into one more specific statement about what the literature has not fully addressed, that directly leads in to how you address it.

From the methods, it is clear that many different datasets and metrics are used in this study, and some sort of illustrative figure or flow chart would be really useful here. For example, you use 3 different precipitation datasets at different scales, have a temporal analysis and a spatial analysis, yearly and monthly data, and several statistical measures. It would be good to have an overview of this at the beginning of the methods section (and/or a figure) to tie these different parts of the study together.

Figure 1: I like that you have included an illustrative example, but it comes very suddenly (I was surprised by "harvest" and thought it was somehow linked to precipitation) and is not fully explained. This example could use its own subsection and then some linkages to exactly what we are looking for in the following precipitation-based results.

Related to the above, the introduction and methods section seem a lot longer than the actual results and discussion of the study. The results section would benefit from more discussion, and ties between sections. For example, many studies are brought up in the introduction, and some could be moved here to compare with your specific results. Also since the methods are heavy on different metrics, the reader could use reminders of what some of these metrics mean from a physical standpoint within the results.

Methods and interpretation:

I have a question on the selection of a critical transition for a given time-series: Can there be a time-series with no critical transition? Currently I get the idea that this time point is selected in every dataset as the maximum rate of change, or "abrupt change of slopes"...which does not necessarily indicate a critical transition, but adjacent years with high variability. I thought it would make more sense to define a critical transition as a step change, where magnitudes or statistical properties "before" and "after" are maximally different. In general, the definition and reasoning to identify a critical transition should be more clear. As it is, referring to changes in precip between two years as a "catastrophic transition" seems tenuous.

The time windows (or data lengths) over which statistical measures are calculated is very small, e.g. 13 or 7 annual data points in all these cases. This leads to some question of statistical significance of trends in the early warning indicators. For example, you highlight several cities out of a much larger pool of data that show these increases in AR and stdev before a critical transition, but is that actually typical? Or are there many cases where these indicators are increasing where there is no critical transition (false positives), or cases where they do not well predict a transition (false negatives)?

I liked the network analysis, but it was hard to go between the table of the regions and Figure 4 - could the table with the regions be made into a colored map that goes into Figure 4? This would tie these regions into the results in more directly and make them easier to discuss.

Minor comments:

Line 7: The first sentence of the abstract could be restructured to not start with "In this study..." as that is apparent.

Line 17: shed new light

Line 55: get rid of "aka" and explain fully. Similarly, in various places, recommend getting rid of term "viz" and explaining fully.

Line 84: cites = cities

Line 100: I don't think PET has been defined, or could use re-defining here

For the AR1 as a measure (e.g. on the y-axis of several figures) – is the measure itself actually the alpha term in Equation 1? Or This was not completely clear to me at first, since the label is just "AR1". Actually, it seems like Equation 1 lines up with Equation 4, and 3 goes with 5, so perhaps this subsection could be better re-organized and less

repetitive.

Line 172: governing dynamics are

Line 188: another statement of a research gap, not needed here really

Line 189: emerge

Line 205: measure

Line 265: You had over 100 cities in this analysis according to the methods but only introduce and discuss these 4, would be good to rationalize that small selection (as they are exemplary, show the largest trends in early warning indicators, etc).

Line 288: "highly assortative with large modularity" needs more expansion

Line 297: responds, presages