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Interactive comment on "Statistical Characterization of Environmental Hot Spots and Hot Moments and Applications in Groundwater Hydrology" *by* Jiancong Chen et al.

Anonymous Referee #1

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This paper, "Statistical Characterization of Environmental Hot Spots and Hot Moments and Applications in Groundwater Hydrology" by Chen and others proposes statistical methods for characterizing ecosystem control points primarily in an ecohydrological context. The paper has many interesting ideas and promising approaches. However, I found the current manuscript structure to be quite convoluted and difficult to follow. With a substantial restructuring around a clear set of hypotheses, I think this paper would be highly appropriate for this journal. I provide some general comments and suggestions below.

1. The paper flips back and forth multiple times among general discussion, case stud-

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ies, and equations. While this could work, the manuscript needs a clear through line and arc to pull this off. The current sections seem jumbled, and I found myself unsure of what was novel versus what was being reviewed. This is particularly notable at the conclusion of the paper, where general comments are made that are very similar to the introduction (i.e., the paper does not build on itself or at least not in a way that invites readers to come along). I would recommend a careful restructuring with clear delineations between the new content and previous work.

2. In the introduction, the authors provide a useful summary of the use of the hot spot and hot moment terminology in several fields, including medicine. The authors claim to combine these definitions around line 40: "we combined these definitions such that, henceforth, HSHMs are referred to as rare locations or events that could exert a disproportionate influence on an ecosystem and which are associated with heightened health or environmental risks." This definition is too broad to be useful, in my opinion. For example, what does disproportionate mean in a quantitative sense? Both the original HSHMs paper (McClain et al., 2003) and the recent conceptual update (Bernhardt et al., 2017) emphasize the idea of variable influence, characterized as response surfaces or distributions. Could the authors of this study useful formalize this definition based on a certain percentage or proportion relative to a process and spatiotemporal domain of interest? For example, is a site that has a denitrification rate that is in the 60th percentile of the studied ecosystem a control point? Can the "hotness" of an ecological process be characterized by its spatiotemporal lumpiness in an easily interpretable way?

3. One of the justifying premises of the paper is that there are not available statistical tools to describe HSHM phenomena (e.g. lines 91 through 93). I think this is generally a weak justification and in this case, clearly incorrect. There are many theoretical and empirical models to simulate HSHM dynamics, including several in just the past few years (Druhan et al., 2014; Abbott et al., 2016; Kolbe et al., 2019; Li et al., 2017; Oldham et al., 2013; Pinay et al., 2015; Zarnetske et al., 2012; Bochet et al., 2020).

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Better integrating this work with the existing literature would clarify what is novel about the contribution and help the reader get up to speed on this important topic.

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