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Hydrology and Earth System Sciences Discussions

Interactive comment on "Using comparative analysis to teach about the nature of nonstationarity in future flood predictions" *by* S. B. Shaw and M. T. Walter

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Overall Comments:

This intriguing paper advocates using a comparative analysis as a teaching technique that can illuminate the underlying physical and hydroclimatic reasons for variations in spatial and temporal flooding variability. I heartily agree with this relevant message and am glad to see this approach being promulgated for the classroom as well as being proposed as a means for evaluating how climate change might affect future flood frequency distributions in different watersheds and regions. The author's teaching exer-

cise illustration is presented clearly and effectively. Especially innovative is the example of how their approach can be used to evaluate the suitability of different types of climate model projections for driving changes in a watershed's dominant flood processes.

Specific Comments and Suggestions:

(1) A unique and novel aspect of this article is the introduction of the comparative analysis framework , therefore the paper would be strengthened by better defining this framework as the authors use it in their study. Are the authors transferring specific methodological tools to the comparative analysis of floods, such as approaches already being used in the social sciences , e.g. Ragin (1989)? Or are they using the term in a more general sense, akin to a geographical or regional analysis that compares basin characteristics and flood processes? Given the examples provided (lines 47 through 60) it seems to be the latter, but because the term "comparative analysis" is central to the title and purpose of the article, I'd like to get a clearer understanding of how the term is being defined in the context of this paper and how this analytical approach is actually being done.

(2) Following on from point (1), I agree with the comment by Sivapalan on the need for providing more details about how comparative analysis is implemented in teaching. The authors provide one effective illustration of a teaching exercise (Section 2). Is this part of a larger pedagogical framework that defines their courses? If not, how do the students develop the "intuitive sense of differences in hydroclimatological drivers" (lines 189-190) which they need in order to complete the exercise? One suggestion for developing such an understanding is U.S. Geological Survey Water-Supply Paper 2375 (1991) on "Hydrologic Events and Floods and Droughts" which presents a state-by-state hydroclimatological description of the principle sources of moisture delivered into the state as well as an overview of the causative mechanisms for each state's major floods and droughts. Also included in this volume is an article on the moisture-delivery pathways and meteorological processes at multiple scales that produce floods throughout the United States (Hirschboeck, 1991). In fact, this "Climate and Floods"

article can be viewed as a “comparative analysis” (in the general sense) of the differences in the causative mechanisms of floods from one part of the country to another. “Climate and Floods” is often used in classrooms for this purpose, including my own courses on “Geographical Hydrology” and “Global and Regional Climatology.”

(3) The authors maintain that a comparative approach has been little used when teaching the topic of flood frequency analysis in the hydrology classroom and this may indeed be true in many academic settings although both Sivapalan and I, in (2) above, provide some classroom examples of similar approaches. I must also echo Sivapalan’s comment about earlier and recent work that should be addressed. There is an established record in the interdisciplinary literature of exploring the causative mechanisms of floods and comparing flood hydrology regionally on this basis. Ward’s (1978) treatise: Floods – A Geographical Perspective is a classic. Vit Klemeŝ has long argued that an interdisciplinary causative mechanism approach is needed in watershed analysis and specifically in flood frequency analysis (e.g., Klemeŝ , 1974; 1982). Furthermore, classifying flood-causing mechanisms to sort out the influence of climate change and nonstationarity on floods has also been investigated previously. This is the goal of “Flood Hydroclimatology,” which I defined in the 1980s, as an alternative hydroclimatic framework for evaluating flood records by questioning the stationarity assumption and re-envisioning flood frequency distributions as being driven by specific storm types embedded within “the history of variation of regional and global networks of changing meteorological features and circulation patterns" (Hirschboeck, 1988, p 45).

(4) In the Conclusions section I was very glad to see the authors’ address the important issue of scale. They note that the “comparative analysis delves into the question of how catchment size influences flood peak per unit area” (lines 311-312) and that “certain processes (such has rapid snowmelt for the winter discharge events and convective rainfall for the summer events) may have a strong scale dependence.”(line316-317). Indeed, an annual peak, or the peak of the entire record, is more likely to be generated by heavy rainfall from a summer convective event in a small drainage basin, than in

a larger drainage basin – even within the same watershed (Hirschboeck, 1991; 2003; Michaud et al., 2001). Scale is such an important factor for flood -weather-climate interactions, that the authors may want to consider expanding this discussion and positioning it earlier in the context of the teaching exercise, rather than as a caveat in the Conclusions section.

Lastly, let me once again echo Sivapalan’s closing comments with my own agreement and support for the ideas and creative approach in this paper. My reason for including references to papers from earlier decades and other disciplinary perspectives (including some of my own) is to affirm the author’s approach as an extremely timely and inventive example of ideas that have been germinating for some time in various sectors. As the pace of climate change accelerates, teaching future hydrologists in innovative ways like those described here, will become essential.

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