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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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We appreciate the thoughtful and insightful comments of Dr. Hirschboeck and Dr. Sivapalan.

Several of the comments overlapped. We will address these first.

A. How is the idea of comparative analysis integrated into the teaching of an entire class, beyond the one exercise presented? (Hirschboeck Comments #2 and #3, Sivapalan Comments #1 & #3)

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Both of the authors (Shaw and Walter) are currently teaching classes that approximately cover hydrology in a changing climate; one is taught at SUNY ESF and the other at Cornell. Both of these classes are something of a work in progress (thus discouraging the authors from being too specific with details), but some additional aspects of the classes will be presented in the revised manuscript to put the exercise in the paper in context.

For instance, Shaw's class involves several additional exercises that fall within the boundaries of comparative analysis. In one, students analyze surface air maps from the National Weather Service to 1) calculate recycling ratios (following Trenberth 1998) for different storm events in different regions and 2) to also roughly track the origin of moisture heading into a region (following Gimeno et al. 2010 and Van der Ent et al. 2010). In another exercise, students 1) evaluate the relationship between precipitation and temperature (a' la the Clausius-Claperyon relationship) for different duration rainfall events in different locations and concurrently 2) evaluate variability of runoff ratios across storm events in different regions to assess dependencies on antecedent conditions. The flooding exercise presented in this paper would follow these additional exercises. Thus, students would have developed some sense of variation in climate drivers in different locations.

In Walter's class (which is co-taught with Dr. Peter Hess, one of the many co-authors of the IPCC reports) the course is organized around the idea of evaluating how hydrologic studies make use of climate studies. For much of the class, students work to assess how the globally distributed climate predictions are translated to regional and watershed level observations. The students apply a level of comparative analysis to tease out differences in linkage between climate predictions and the terrestrial hydrology among different regions.

The authors were not previously familiar with USGS Water Supply Paper 4375. We found this report to be a valuable source of descriptive information that provides a nice overview of the hydroclimatology in different regions of the US. In the revisions, we plan

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to briefly discuss this resource and suggest how it could be used to provide background prior to the exercise presented in the manuscript.

Dr. Sivapalan had the slightly more specific suggestion to also put this paper in context regarding other recent approaches to use hydrologic signatures. As discussed above, since the authors have used the flooding exercise within hydroclimatology classes that have more of a focus on external drivers than innate watershed features, the authors have not, in practice, extensively focused on analyzing signatures of innate watershed response (i.e. recession, flow duration curve, etc.). But, the authors will add some text in the revised manuscript noting other recent efforts (e.g. papers of Sivaplan and associates) to make use of signatures to understand hydrologic processes and the possibility of incorporating these in the future.

B. Broaden the literature review of comparative analysis and process controls on flooding. (Hirschboeck Comment # 3, Sivapalan Comment #3)

We thank the reviewers for the additional references regarding comparative analysis. We will incorporate these references (and several others we have come across since submitting the original manuscript) into the revised manuscript to provide a fuller picture of how and when comparative analysis has been used previously. In particular we will emphasize in the revisions that the idea of comparative analysis is not so new, but that it is time to revisit it and build on existing (but not always broadly considered) work. Additionally, we will note some of the specific work done to classify flood causation in the past (Eagleson 1972, Klemes 1974, Ward 1978, and Hirschboeck 1988).

Other comments:

C. Expand discussion of importance of scale (Hirschboeck Comment #4)

The authors agree that issues of scale are important. However, because this paper is partially about flood analysis and partially about pedagogy, it would seem that getting too extensively into questions of scale would tip the balance too much to a review of

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methods of flood analysis. We will add an additional line to the revised manuscript indicating our reasoning for omitting further analysis of the important issue of scaling.

D. Better define idea of comparative analysis (Hirschboeck Comment #1)

Several lines will be added that specifically define comparative analysis in the more general sense outlined by Dr. Hirschboeck. Namely, we will note in the revised manuscript that we use the term "comparative analysis" in regards to the comparison of processes in different geographical regions. Methodologically, the approach relies on using relatively self-evident distinctions among regions to elucidate evidence of significant differences in hydroclimatological processes.

E. Provide Some Details of Further Analyses that Could Follow from the Descriptive Comparison (Sivapalan Comment #5)

Dr. Sivapalan raises the idea of having students develop simple models to quantify the descriptive trends. We will add several lines suggesting how the descriptive analysis could be extended for more advanced students. For instance, students could quantify seasonality of flood causation or construct mixed distribution models of flood frequency (e.g. Hirschboeck 1987, Shaw and Riha 2011), or students could develop models to explore spatial and temporal patterns (e.g. Roderick and Farquhar 2011, Merz and Bloeschl 2011).

However, we do note that a second piece of the exercise presented in the paper was the idea of knowing when or how to modify existing statistical models to account for changes in different climate drivers in the future. This component in itself is already a quantitative extension of the comparison of signatures initially presented in the paper.

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