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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Complex networks for streamflow dynamics" *by* B. Sivakumar and F. M. Woldemeskel

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Response to Referee Comment – S. A. Archfield (RC C2859):

We thank S. A. Archfield for her very positive and constructive comments on our work as well as for her useful suggestions to further improve our manuscript. We agree with all her comments and suggested improvements. We have also particularly benefited from the two more recent publications (Kiang et al., 2013; Patil and Stieglitz, 2012) suggested by the reviewer, as they certainly allow us to view our work in an even better perspective. We will incorporate the comments and suggestions in the revised manuscript, including appropriate reference to, and discussion of, the above two publications. Our responses to the individual comments are as follows.

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Interactive Discussion

Discussion Paper

Referee Comment: I found the manuscript to be well written and innovative. Understanding network connectivity is critical in hydrology, particularly for the estimation of streamflow at ungaged locations as well as for assessing gaps and redundancies in monitoring networks. This manuscript provides a comprehensive look at the US streamgaging network using a novel approach for this assessment.

Author Response: We thank the reviewer for her very positive comments on our manuscript.

Referee Comment: It should be noted that correlation between streamflow time series has been completed for the United States as part of a recent network analysis conducted by Kiang et al. (2013). This study looked at correlations between daily streamflow but did not take the next step of using a network-based approach, as presented in this manuscript. I believe this report is worth reviewing and citing because the results support much of the observations made here. I suggest this manuscript be accepted subject to only minor revision.

Author Response: We thank the reviewer for directing us to the USGS Report (A National Streamflow Network Gap Analysis) by Kiang et al. (2013). The Report presents an extensive analysis of streamflow data across the United States, including correlation, coefficient of variation (CV), and several other statistics that are relevant to the nature and interpretations of our analysis. We will cite the Report and will also attempt to offer interpretations of our results in the context of the results presented in the Report. The regional analysis based on Hydrologic Unit Code (HUC) (and also state-wide analysis) presented in the Report are also particularly useful to view our network analysis (and interpolation/extrapolation and catchment classification) in the context of HUC. The data considered in the Report are also an updated version of the data we used in our study, both in the number of gages and in the length of records. In view of these, we intend to apply, in a future study, the network approach to examine connections in streamflow within specific HUC regions using the updated streamflow data.

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Referee Comment: Section 3: Please clarify which dataset of streamgages were used and if the streamgages were considered to have relatively unaltered contributing catchments. Also state how the monthly values were computed (sum, mean, etc).

Author Response: The streamflow data were an earlier version made available by USGS several years ago (http://nwis.waterdata.usgs.gov/nwis). The data were for a network of 639 stations and for the period 1951–2003, and mean monthly values. As mentioned in the manuscript, the data (or a part or variant of it) had previously been used by Sivakumar (2003), Tootle and Piechota (2006), and Sivakumar and Singh (2012), among others. Since some of these studies have examined the nonlinear dynamic aspects and catchment classification, we thought analysis of the same data set would be helpful for interpretations. However, an updated version of the data has been made available by USGS since then. The updated data have been used by many studies, including the ones suggsted by the reviewer (Patil and Stieglitz, 2012; Kiang et al., 2013. We intend to use the updated version of the data in our future studies (including network analysis in the context of HUC). We will include some additional information in the revised manuscript to make it even clearer on the data used.

Referee Comment: Section 3 list of observations: How do these observations link to any potential biases in your results or hypotheses about network connections?

Author Response: We thought, at least from a study area perspective, it would be helpful to highlight the extent of differences in the basin/streamflow characteristics across the 639 stations in the United States. The clustering coefficient results may be interpreted in terms of basin/streamflow characteristics, such as drainage area, mean of flow, coefficient of variation of flow, etc. We realize, however, we did not properly do this in our manuscript, as such is a slightly complicated process. We will attempt to do this during the revision and/or modify Section 3, as appropriate.

Referee Comment: Section 4: By “linear correlation-based analysis,” do you mean the Pearson correlation coefficient? If so, did you take the logarithms of the streamflow

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values before computing the correlations?

Author Response: Yes, it is Pearson correlation coefficient. We, however, did not take the logarithms of the streamflow values before computing the correlations. We admit that the Pearson correlation coefficient is slightly sensitive to outliers in the data, and so understand the reviewer's point. However, the impact of this sensitivity is minimal for monthly streamflow when compared to streamflow at shorter timescales (e.g. daily), as the monthly data assumes approximately normal distribution from additive errors at finer timescales through the central limit theorem (Anderson, 2010). We will acknowledge and briefly discuss this issue in the revised version.

Referee Comment: There was a recent publication in HESS that also looked at distance as a proxy for similarity in the US streamgage network. I believe this paper should also be cited (Sopan and Stieglitz, 2012).

Author Response: We thank the reviewer for directing us to the paper by Patil and Stieglitz (2012). The paper is indeed relevant to our study both in the context of connection/similarity between catchments and in the context of streamflow data across US. We will, therefore, cite the paper, and we also hope to offer some useful interpretations.

References

Anderson, C. J.: The central limit theorem, in: Corsini's Encyclopedia of Psychology, edited by: Wiener, I. B. and Craighead, W. E., John Wiley & Sons Inc., New Jersey, USA, 2010.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 7255, 2014.