Stochastic simulation of streamflow and spatial extremes: a continuous, wavelet-based approach

Review report by **Dr Sandhya Patidar**

The paper presents a continuous wavelet-based phase randomisation approach for the stochastic generation of streamflow time series. This is an interesting paper that substantially extends the original techniques developed in [1] for stochastic simulation of streamflow using Fourier transformation based phase randomisation. The original method, presented in [1] is associated with certain limitations such as application of Fourier transformation does not account for the non-stationarities in time series and resulted in an underestimation of spatial dependencies (e.g. cross-correlation) in both daily discharge and extreme events across the multiple sites. The present paper address some of the limitations observed in [1] by replacing Fourier transformation with a complex wavelet-based approach. The efficiency of original method has been evaluated to generate realistic series for distributional and temporal correlation characteristics and is validate through the application across four catchments in Switzerland. The proposed model is applied to a large dataset of 671 catchments in the contiguous United States and the efficiency of the model has been evaluated by assessing its ability to capture distributional and temporal characteristics at individual sites along with the spatial dependencies across the multiple sites, and extreme events (floods) including duration and volume.

Some general comments –

Section 1 - Considering the theme of paper that signifies the application of wavelet approach, the Introduction section presents an interesting critical review on recently developed/applied modelling schematics that involves wavelet-based phase randomisation as a key approach.

Line 70-73: To add clarity it would be helpful if the authors' team add some brief explanation on how data normalisation procedure and back transformation impacts the spatial dependencies.

Line 87-88: Please add some clarity on how continuous wavelet transform is more effective than a discrete wavelet transforms in minimising/overcoming issues around the long-term periodicities and/or non-stationarities. Is there any specific studies carried out to investigate such issues.

Section 2 - Theoretical background section provides suffiecient details on the wavelet decomposition approach.

Section 3 Data – For illustration and validation purposes, dataset are organised in three different region based on the general hydrological characteristics. It is not clear which specific properties has been used and how rigorously they have been appied. I think, this work could have benefitted if Authors' have considered using some form of clustering approaches (e.g. K-mean) based on key characterisetic for clustering the sites.

Section 3 Method - It seems that the model interconnect different site only as part of step 1 (phase randomisation/perturbation applied throught the medium of white noise). All the remaing steps (1-4 steps) are applied independently across all the sites. I think the approach is appropriate. A separate Kappa distribution is fitted for each day for a 30-day window to factor in seasonal differences. I have a minor concern here, What is the motivation for the selection of a **30** day window, how does it effect data with different seasonal periods across different sites (e.g. may be one site having monthly seasonality but other having weekly seasonal characteristics or say over a three months period).

Section 4

A robust evaluation has been conducted that includes careful seletion of sites (distinct and representative). Statistics used for comparision are appropriate and results are well explained. Some minor comments -

Figure 9 – Visually observed and simulated looks in good agreement for occurance of POT events but for a robust comparision some measurements should bave been used in parallel.

Figure 10 gives a good illustration of how spatial dependencies could be effected among th sites with respect ot the Euclidean distance. However, for the readers benefit it would be appreciate if Authors' consider to provide few sentences to explain F-madograms plots, specifically, what should a relative difference of 0.05 in observed and simulated values should be interpreted.

Section 5 and 6 – Overall good and capture key aspects of the paper.

Reference

[1] Manuela I. Brunner, András Bárdossy, and Reinhard Furrer, *Technical note: Stochastic simulation of streamflow time series using phase randomization,* Hydrol. Earth Syst. Sci., 23, 3175–3187, 2019.