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www.hydrol-earth-syst-sci-discuss.net/11/C5013/2014/

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Variability of low flow magnitudes in the Upper Colorado River Basin: identifying trends and relative role of large-scale climate dynamics" *by* M. Pournasiri Poshtiri and I. Pal

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Thank you for your constructive review and feedbacks. Each point raised is significant and we were happy to address all of them. Our response to each comment is written below following each referee comment and we incorporated them in the manuscript as track changes, please see the supplement.

General comment The paper by Pournasiri Poshtiri and Pal deals with the topic of natural low water flows variability and predictability, through their connection with large-

scale climate forcing. The paper is clearly in the scope of the journal of Hydrology and Earth System Sciences. The text makes enjoyable to read and is well written. The aim of the paper is clearly stated through a couple of science questions. But despite interesting subject and data quality and quantity, the paper lacks in research depth and is far from being perfect in form.

[Reply] We have re-written many segments of the paper, following your suggestions, please see the new version with track changes.

Some methodological aspects are not presented/argued by authors (e.g. the use of the power spectrum wavelets).

[Reply] We have now presented methodological aspects of power spectrum wavelets. Please check annotated manuscript, page 9, lines 182-197.

While the authors try to find correlations between large scale predictors and low flows variability, their conclusions are somewhat unconclusive and no clear hypothesized process cascade linking large-scale climate patterns and low flow magnitudes in the UCRB emerges from their experiment. Science questions of the introduction do no really get clear answers from the environment-to-circulation approach adopted by authors.

[Reply] We have re-written the conclusion part of the paper, please see the new version with track changes.

In addition, the study area is not presented and the physiographical context of the study basins remains largely unknown to the reader.

[Reply] We have added a revised map of the study basin. Please check Figure 1 that includes the physiographical attributes on a GIS setting and discussed in the paper (please also check annotated manuscript, page 6, lines 115-119).

Major changes are necessary to produce a well-documented and solidly built paper and to make the manuscript fit the standards of the journal of Hydrology and Earth

System Sciences.

[Reply] Please note the above changes, and also specific changes as follows:

Specific points The abstract might be more informative about research findings of authors on research questions they raised in italics.

[Reply] We have re-written the abstract, incorporating research findings specific to research questions raised there.

p.8781 line 28: is it an enhancement of potential or actual evapo-transpiration which is expected?

[Reply] It is an enhancement of potential evapo-transpiration (Milly et al. 2005; Christensen et al., 2007; Seager et al., 2007).

p.8781 line 28: at least one reference drawn from the scientific literature should be provided by authors.

[Reply] Done. Please check annotated manuscript, page 4, lines 72-75.

p.8783 2 Data: A detailed list on hydro-climatological databases treated by authors is presented. Little details were provided about the homogeneity/quality of those databases: are they potentially containing spatial and/or temporal biases? As those biases could impact the trend analysis and regional flow variability study performed by authors, they should provide arguments in favor of using those databases to match the goal of their experiment.

[Reply] We have now incorporated a detailed discussion on the quality of the data, please check Supplementary Information Section I.

The methodological framework of time series analysis is not sufficiently detailed and argued. Without providing a complete presentation of the Mann-Kendall test and the power spectrum wavelet method, for a sake of understanding authors should at least explain a little bit more how these widely-used time series analysis tools are working

and to what extent they might help them to answer their scientific questions.

[Reply] We have now added a description of Mann-Kendall test and Wavelet Power-Spectrum analyses in the main text, please check annotated manuscript, page 9, lines 182-197.

p. 8789 line 9: If I am not mistaken, nowhere in their paper, authors refer to physiographical factors for explaining spatial variability of trends. This point should be discussed.

[Reply] We have included discussions on physiographic factors explaining spatial variability of results, please check annotated manuscript, section 4.1.

Technical points p.8782 line 17 : spatial instead of special

[Reply] Done, please check annotated manuscript, page 5, line 89.

Table 1: HESS Manuscript Preparation Guidelines for Authors mentions that the use of SI units is mandatory. Please use cms instead of cfs. [Reply] Done. Please check Table 1.

Content of the Note below the table suggests that columns LAT_GAGE and LONG_GAGE are missing in the table.

[Reply] LAT_GAGE and LONG_GAGE are included in Table 1-A.

From Table 1, it would be appreciable to get for each station, the drainage area, the altitude of the hydrometric station, streamflow time series length as well the time period covered by the streamflow series.

[Reply] Done, please check Table 1-A.

Table 2: Please give in the title the time period for which the correlation coefficients were calculated.

[Reply] Done, please check Table 2

Table 3: the last column should be removed.

[Reply] Done.

Figure 1: the design of the map is really poor. Authors should improve the content/quality of the map through additional information like topography, geographical details (e.g. parallels of latitudes and meridians) and hydrographic network (main rivers and catchment limits). Moreover, the map is too small and no graphical scale is provided! It is suggested to authors to use a GIS and couple on the same figure a big map at a regional scale presenting the study area and an other small one at a larger scale (continental scale). This will help non expert reader to better locate the region of interest and check that hydrometric stations are indeed controlling headwater basins.

[Reply] Done. Please check Figure 1.

Figure 2: the use of different symbols for time series makes them undistinguashable. The authors should find a way to improve the readability of the figure. Grouping time series with the same symbology per natural regions might be a solution. A fragmented time series figured with red crosses and representing constant standardized values appears on the figure but is not labelled in the caption: : :This point should be clarified.

[Reply] This comment, along with the comment of Reviewer 2 was incorporated to develop new Figure 2. Please check Figure 2.

Figure 3: Quality is poor. Among things to change: increasing image resolution, banning abbreviations like lat, insig; adding a graphical scale to the maps ; representing trend magnitude using light blue/dark blue or light red/dark red instead of a color ranges. In addition, Title of Figure 3 do not clearly explains what is represented on the Figure. . .is it the kendall tau ?

[Reply] We have now enhanced the quality of Figure 3, also in the caption added what the bubbles indicate. It is Sen's estimate of the trend value in cms/day/year and the sign and significance of the trend is shown in color. Sig = significant; insig = insignificant.

Figure 4 : What is the meaning of the CFC abbreviation used in the figure captions ?

[Reply] It should be CMS/DAY. Please check Figure 4.

Figure 5 : completely unreadable !!

[Reply] So we conducted a Principal Component Analysis on the low flow indices data, and the PC1 gave us a variance of nearly 40-60% for annual and seasonal (Figure S4) low flows across the basin. We have shown the correlation analyses between climate and PC1 to make it simpler (Figure 5 and S5), which yielded significant correlation patterns with northern Pacific (and tropical Pacific) surface temperature known as Interdecadal Pacific Oscillation (IPO by Dai et al. 2013) related to Pacific Decadal Oscillation (PDO) and the ENSO. McCabe et al (2004) indicated that southwestern US droughts are associated with PDO. Because low flow magnitude is a decent indicator of hydrological droughts (IPCC), our study confirms the previous findings and establishes the associations between low flow patterns and droughts and the large-scale climate pattern.

References Christensen N.S., and Lettenmeier, D.P.: A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River Basin, Hydrology and Earth System Sciences, 11, 1417–1434, 2007.

Dai, A.: The influence of the Inter-decadal Pacific Oscillation on U.S. precipitation during 1923-2010, Climate Dynamics, 41, 633-646, doi: 10.1007/s00382-012-1446-5, 2013.

McCabe, G.J., Palecki, M.A., and Betancourt, J.L.: Pacific and Atlantic Ocean influences on multidecadal drought frequency in the United States, Proceedings of the National Academy of Sciences, 101, 4136-4141, 2004.

Milly, P.C.D., Dunne, K.A., and Vecchia, A.V.: Global pattern of trends in streamflow and water availability in a changing climate: Nature, 438, 347–350, doi:10.1038/nature04312, 2005.

Seager, R., Ting, M., Held, I., Kushnir, Y., Lu, J., Vecchi, G., Huang, H.P., Harnik, N., Leetmaa, A., Lau, N.C., Li, C., Velez, J., and Naik, N.: Model projections of an imminent transition to a more arid climate in southwestern North America, Science, 316, 1181, doi: 10.1126/science.1139601, 2007.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C5013/2014/hessd-11-C5013-2014-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 8779, 2014.