Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2020-297-AC1, 2021

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Drought monitoring and prediction in climate vulnerable Pakistan: Integrating hydrologic and meteorologic perspectives" *by* Taimoor Akhtar et al.

Taimoor Akhtar et al.

akhtart@uoguelph.ca

Received and published: 1 April 2021

General Comment: The paper deals with applying both a climatological (SPEI) and hydrological (SSI) drought index to assess their combined application on drought monitoring over four catchments in Pakistan (and Afghanistan). While the methods they applied are very straightforward, there are some issues which should be addressed to increase the quality of manuscript and to make it publishable by HESS

Response: We sincerely thank the referee for insightful comments that should surely help us in improving the quality of our manuscript. We agree that the methods used in

understanding the relationships between SPEI and SSI are straightforward and can be expanded beyond analyzing correlations, to improve the quality of our analysis. Thus, as also suggested by the referee, we will include a multivariate regression analysis in the revised manuscript to better represent the spatiotemporal correlations (with lead time) between SPEI and SSI for the 4 catchments analyzed in this study. We believe that the multi-variate analysis could be valuable in early streamflow drought identification in these catchments.

Point-by-point Reply to Comments:

Line 126: what's the spatial resolution for this dataset?

Response: The spatial resolution of CRU TS 4.03 0.5x0.5 degrees (Harris et al., 2020). We will mention the spatial and temporal resolution in the revised submission.

Lines 126-128: Add some examples on correlation values between CRU TS4.3 and observed data in Pakistan, especially the study area.

Response: We thank the referee for this valuable comment. We have computed correlations between CRU TS4.3 and observed precipitation (mm) of six stations within the study area (4 catchments), and results are provided in the attached Figure 1. The stations analyzed and corresponding catchments (mentioned within brackets) to which they belong to are: Jhelum (Jhelum), Peshawar (Kabul), Chitral (Kabul), Gilgit (Indus), Kotli (Jhelum) and Muzaffarabad (Jhelum). These stations are maintained by Pakistan Meteorological Department (PMD). In Figure 1, observed precipitation (mm) are compared to corresponding values of nearest grid point available in the CRU data sets, with R squared values ranging from 0.5-0.75. We will include these comparisons in the revised manuscript as well, and will also include more stations, if available.

Lines 129-134: Is data used for streamflow analyses regulated or unregulated? Line 203: What's the logic behind choosing -1 as threshold value for drought events? while the authors chose -1 as the threshold, 0 should be replaced by -1 at like 211, (I_i<-1 and I_i-1>=-1).

Response: Lines 129-134: The streamflow records at 3 of 4 locations (i.e., Chenab at Marala Barrage, Jhelum at Mangla Reservoir (upstream) and Indus at Tarbela Reservoir (upstream)) analyzed in this study are unregulated. There are some run-of-river control structures in these river systems, however (upstream of the aforementioned stations). The river Kabul has diversion structures upstream of the Nowshera gage (which is used as the streamflow record station for Kabul in this study). While, the withdrawals from these structures have historically been a small proportion of streamflows in the past, they may increase significantly in the future. This study assumes that withdrawals are negligible. We will clearly state this assumption in the revised manuscript. Line 203: For drought events we are using the threshold definition proposed by McKee et al. (1993), where drought events are defined as periods where indicator values were continuously negative with at least one month's indicator value being below -1.0. We realize that line 211 is misleading in this context and we will revise it in the updated manuscript.

Lines 240-246: Even using the visual judgment, Log-logistic is not the best distribution for some cases, e.g. Kabul-July, Indus-July, Chenab-July and Chenab-January. As the authors also indicated, the best probability distribution cannot be ascertained visually. There are many goodness-of-fit tests which should be used here and the results should be presented to support the choice of best distribution function for each catchment/month combination.

Response: We thank the referee for this comment and understand that goodness of fit test should be presented along with the visual representation to support the choice of best distribution. Therefore we will apply the Kolmogorov–Smirnov test to ascertain the most appropriate distribution, and include our findings in the revised manuscript.

Table 1 and Figures 5 and 6: again while -1 is the threshold for drought detection (Table 1 and inside the text), Figures are based as 0 as the threshold! Response: In both the

figures 0 does not represent the threshold for drought events. It shows the level below which we can call it relatively drier period compared to the period above 0 threshold. However, we will revise both figures to only mark drought events in red, in order to remain consistent with the drought definition.

Figure 8 and Lines 287-288: why cross-correlations are calculated with SSI-1? Why not SSI-3? Response: The attached Figure 2 with this supplement includes cross-correlations with SSI-3 and SSI-6. We will include this in the revised submission.

Line 308: What do authors mean by Lagged by 2 while Figure 9 is not about lag issue? Response: In Figure 9 for SSI-3 double accumulation in place as streamflow is already an accumulation of Precipitation. Therefore, a lag of 2 months is added in SSI-3 to avoid double accumulation of precipitation.

Section 4-4: I suggest that instead of this section which I believe can be removed from the text without losing any specific information, authors can develop some multivariate regression equations to predict SSI-1 using SPEI-3 with 1 to 3 months lead-time. They can choose the wettest and driest months as sample and develop the relationship based on those SPEIs with highest correlation values.

Response: We sincerely thank the referee for this valuable suggestion. We agree that analysis of the relationship between SSI and SPEI should be beyond looking at correlations only. We will include a multivariate regression analysis in the revised manuscript to better represent the spatiotemporal correlations (with lead time) between SPEI and SSI for the 4 catchments analyzed in this study.

References: Harris, I., Osborn, T.J., Jones, P. et al. Version 4 of the CRU TS monthly high-resolution gridded multivariate climate dataset. Sci Data 7, 109 (2020).

McKee, T. B., Doesken, N. J., and Kleist, J.: The relationship of drought frequency and duration of time scales, in: Eighth Conference on Applied Climatology, American Meteorological Society, 1993.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-297, 2020.

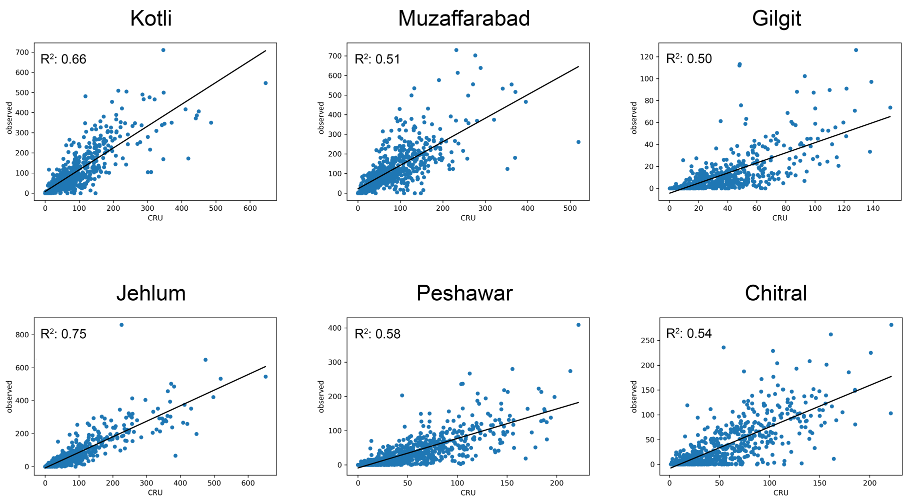

Fig. 1. Comparison of monthly CRU precipitation with station observations.

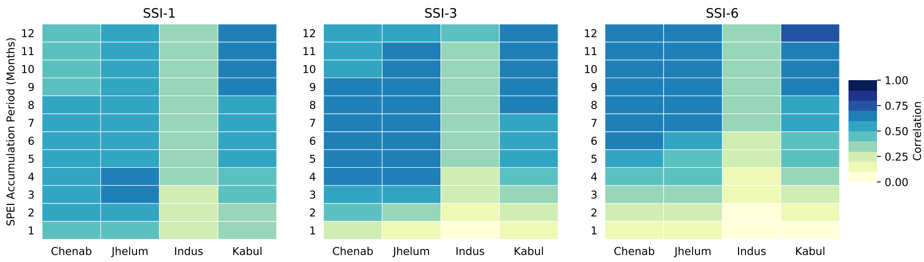

Fig. 2. Heatmap of cross-correlations between SSI-1 and SPEI (for different accumulation periods) for the four Upper Indus catchments, i.e., Chenab, Jhelum, Indus and Kabul.