Responses to the comments from Reviewer #1

We are very grateful to the Reviewer for the positive and careful review. The thoughtful comments have helped improve the manuscript. The reviewer's comments are italicized and our responses immediately follow.

This paper examines hydrological drought in managed river basins in China. Based on the 29-year NMME forecasts, they compared the skill of hydrological drought forecasts between the naturalized and observed conditions. They found that human intervention out weighted the climate variability for hydrological drought forecasts. The paper is well written. I recommend to be published after minor revisions. My specific comments are listed below.

Response: We would like to thank the reviewer for the positive comments. Please see our responses below.

Statistical significance: This may be the weakness of this paper. You compared the correlation between naturalized and observed SPI or SSI. There is no statistical assessment. For example: Fig2. Some gauge like Xunhua, the differences are significant, but differences for gauge Lijin may be not. You need to add statistical significance test to results.

Response: Thanks for the comments. We have incorporated the statistical significance testing and revised the manuscript as follows, where Fig. 2 is Fig. 5 now due new addition of three figure before it.

"The correlations for observed streamflow are significantly lower than for naturalized streamflow for gauges from Xunhua down to Huayuankou, with p values less than 0.01 (Figs. 5b-5j). There is also a significant difference in correlation for Gaocun gauge with $p<0.05$ (Fig. 5k), but the difference is not statistically significant at 90% level for Lijin gauge with $p>0.1$ (Fig. 5l)."

Is SSI similar to standardized runoff index (Shukla and Wood 2008) except you use streamflow?

Response: Exactly. We have clarified it in the revised manuscript as follows:

" Note that SSI was similar to the standardized runoff index (SRI) defined by Shukla and Wood (2008), except that streamflow was used here for a standardization."

Section 2.3 Please add more details For the VIC simulation, what are the sources for daily precipitation and temperature time series used to derive forcings? Did you run the VIC model for these 12 gauge sites or the whole domain? Did you use the VIC in the water balance mode (no observed radiation terms)? which version?

Response: Thanks for the comment. We have clarified the information for the VIC simulation as follows:

"The observed meteorological forcing datasets including daily precipitation, daily maximum and minimum surface air temperature, and surface wind were interpolated from 324 China

Meteorological Administration stations. And the VIC model version 4.0.5 was used to predict runoff in a water balance mode over the entire Yellow River basin with 1321 grid cells at 0.25-degree resolution (Yuan et al., 2016)."

Drought is usually defined as persistent low flow conditions. Does naturalized drought persist longer? Please comment on the persistence of low flow (SSI) conditions.

Response: In this study, the monthly streamflow records were converted into percentiles to represent the low flow conditions at seasonal time scale. A hydrological drought event was defined as follows:

"A threshold of -0.8 was used to represent a drought condition for both SPI and SSI. And a hydrological drought event was selected when the SSI was below -0.8 for at least 3 continuous months (Yuan and Wood, 2013)…"

As shown in Figure 5b (Figure 8b in the revised manuscript), the naturalized drought persists a little longer than the observed streamflow at upper gauges, suggesting the positive influence of human intervention. However, the former is basically shorter than the latter at middle and lower gauges, mainly due to intensive human water consumption. We clarified the duration changes in the manuscript as follows:

" For the drought duration in natural conditions, it is generally longer over upper reaches which is again due to a drier climate (Fig. 8b). With human interventions, there is a decrease in drought duration for the upper gauges down to Xiaheyan gauge. This suggests that seasonality of human interventions reduces the persistency of drought over the upper reaches of the Yellow River basin. From Shizuishan gauge (the 6^{th} gauge in Fig. 8b) down to the outlet, the duration of hydrological drought increases by 12%-83% under human interventions."

You used NMME forecasts. Did you perform hydroclimate forecasts using VIC for each model separately and then took the ensemble means? How exactly did you process the NMME data? Readers need more details on that.

Response: Yes, the VIC model was driven by each ensemble members of nine NMME models with a grand ensemble of 99 realizations, and ensemble means were then calculated to evaluate the deterministic forecast skill. In addition, all 99 realizations were used directly to evaluate the probabilistic forecast skill.

The downscaling process is the same as Yuan (2016). To have this paper self-contained, we have added some descriptions as follows:

"Thirdly, a grand ensemble of 99 realizations from eight North American Multimodel Ensemble (NMME; Kirtman et al., 2014) models was used to force hydrological models to generate the NMME/VIC hindcast dataset (Yuan, 2016). Here, the 1-degree NMME global hindcasts of monthly precipitation and temperature were bilinearly interpolated into 0.25-degree, the interpolated monthly hindcasts for each calendar month and each NMME model were then bias-corrected independently against observations by using the quantile-mapping method (Wood et al., 2002) in a cross-validation mode (i.e., dropping observation and forecast in the target year when building the climatology), and these bias-corrected monthly hindcasts were finally temporally disaggregated to daily by historical sampling and rescaling (Yuan, 2016)."

You stated seasonal cycle plays a role in drought. (page 5 response time is different for summer and winter). How large is the precipitation seasonal cycle?

Response: Thanks for the comment, we have added a figure to show the precipitation seasonal cycle (Figure 2 in the revised manuscript), and have clarified the seasonal cycle as follows:

"Most precipitation over Yellow River occurs in summer season due to the influence of East Asian monsoon, resulting in a strong seasonality of precipitation, with more than 80% of annual precipitation falls within May-September (Fig. 2)."

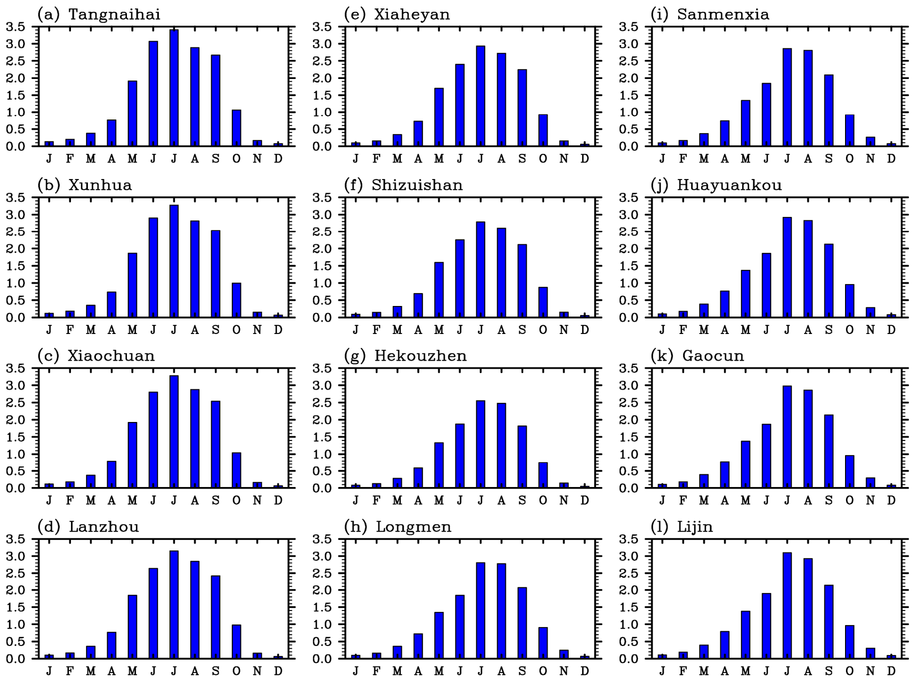

Figure 2. Monthly mean rainfall (mm/day) averaged over 1961-2010 for each sub-basin.

References:

Shukla, S., and Wood, A. W.: Use of a standardized runoff index for characterizing hydrologic drought, Geophys. Res. Lett., 35, L02405, doi:10.1029/2007GL032487, 2008.

Wood, A. W., Mauer, E. P., Kumar, A., and Lettenmaier, D. P.: Long-range experimental hydrologic forecasting for the eastern United States, J. Geophys. Res., 107, 4429, doi:10.1029/2001JD000659, 2002.

Yuan, X.: An experimental seasonal hydrological forecasting system over the Yellow River basin – Part 2: The added value from climate forecast models, Hydrol. Earth Syst. Sci., 20, 2453–2466, doi:10.5194/hess-20-2453-2016, 2016.