Supplementary material

Evaluating the impacts of climate change and vegetation restoration on the hydrological cycle over the Loess Plateau, China

Shuai Yang [1,2], Tingting Kang [1,2], Jingyi Bu [1,2], Jiahao Chen [1,2], Yanchun Gao [1*]

[1] Key Laboratory of Water Cycle and Related Land Surface Processes, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

[2] University of the Chinese Academy of Sciences, Beijing 100049, China

* Correspondence: gaoyanc@igsnrr.ac.cn; Tel.: +86-01064888991

1. Statistical methods

The Pearson correlation coefficient (r) was adopted to detect the relationship between hydrological variables and meteorological variables, calculated as follows:

$$r = \frac{\sum_{i=1}^{n}\left(Q_{i,s} - \overline{Q_s}\right)\left(Q_{i,o} - \overline{Q_o}\right)}{\sqrt{\sum_{i=1}^{n}\left(Q_{i,s} - \overline{Q_s}\right)^2} \cdot \sqrt{\sum_{i=1}^{n}\left(Q_{i,o} - \overline{Q_o}\right)^2}} \quad \text{(S1)}$$

The Mann-Kendall test (M-K test) was employed to quantify the significance of the possible trends of a time series in this study. As a nonparametric test, the M-K test provides more robust results against outliers and skewed distributions and has been widely used in the fields of hydrology, climatology, and meteorology [1, 2]. The statistic S of the M-K test, defined as the proportion of concordant pairs minus the proportion of discordant pairs in the sample, was used to detect the temporal trend:

$$S = \sum_{i=1}^{n-1}\sum_{j=i+1}^{n} sgn\left(X_j - X_i\right) \quad \text{(S2)}$$

$$sgn\left(X_j - X\right) = \begin{cases} 1 & , \quad X_j - X_i > 0 \\ 0 & , \quad X_j - X_i = 0 \\ -1 & , \quad X_j - X_i < 0 \end{cases} \quad \text{(S3)}$$

where X_i and X_j were the data values in the time series and n was the size of the sample. The standardized test statistic Z can be calculated

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}} & , \quad S > 0 \\ 0 & , \quad S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & , \quad S < 0 \end{cases} \quad \text{(S4)}$$

If $|Z| > Z_{1-\alpha/2}$, the null hypothesis of no trend would be rejected at a significance level of α. The time series presents a positive trend when $Z > 0$, while it presents a negative trend when $Z < 0$. The magnitude of trend was calculated by Sen's slope β based on Nonparametric Theil–Sen (TS) Linear Regressions [3]:

$$\beta = median\left(\frac{X_j - X_i}{j - i}\right) \quad , \quad \forall\, i < j \quad \text{(S5)}$$

where the positive value of β shows an upward trend, and the negative value shows a downward trend.

2. Determination of typical grids cells

The implement of GGP has resulted in drastic land use/cover change. This study aimed to explore the impacts of CC and LUCC on hydrologic processes. However, the VIC grid cell was a 0.083°×0.083° pixel that contained several land cover types and vegetation conversions, which may strengthen or weaken, even offset the impacts, especially when coupled with the change in climate. Here, we focused on three land cover types which were dominant vegetation types and widely distributed in the Loess Plateau, i.e. cropland (uc), grassland (ug), woodland (uw), and three vegetation conversion modes which were closely related to GGP, i.e. conversion of cropland to grassland (cg), conversion of cropland to woodland (cw), conversion of grassland to woodland (gw). Therefore, we extracted the six kinds of typical grid cells based on two LULC maps and according to the method shown in Table S1.

The typical vegetation grid cells were determined based on LULC1990 when more than 90% of the grid cell was one of the three typical vegetation types. The determination of conversion grid cell was based on LULC1990 and LULC2010. For example, a cg grid cell was determined when the grid cell was dominant by cropland and grassland for more than 70% in LULC1990 and LULC2010, respectively, and the decrease of cropland and increase of grassland both exceed 30% from LULC1990 to LULC2010. The numbers of six kinds of grid cells were 151(uc), 1493(ug), 519(uw), 317(cg), 102(cw), 81(gw). The three kinds of vegetation VIC grid cells (i.e. uc, ug, uw) were used to detected the response of HVs to climate change, while the three kinds of conversion grid cells (i.e. cg, cw, gw) were used to investigate the impact of typical land cover conversion on hydrologic processes, as shown in section 3.3.

Table S1. Determination method of six target VIC grid cells of three typical vegetation and three vegetation conversion modes.

Pixel type	LULC 1990			LULC 2010			cdiff	gdiff	wdiff
	Cropland	Glassland	Woodland	Cropland	Glassland	Woodland			
Unconverted cropland(uc)	> 90%			> 90%					
Unconverted grassland(ug)		> 90%			> 90%				
Unconverted woodland(uw)			> 90%			> 90%			
Cropland to grassland(cg)	> 70%				> 70%		< -30%	> 30%	
Cropland to woodland(cw)	> 70%					> 70%	< -30%		> 30%
Grassland to woodland(gw)		> 70%				> 70%		< -30%	> 30%

*cdiff, gdiff, and wdiff mean the differences in percentage of cropland, grassland, and woodland between LULC2010 and LULC1990, respectively.

References

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