Supplementary Materials – Equations

Nash-Sutcliffe efficiency (NSE), percent bias (PBIAS), and ratio of the root mean square error to the standard deviation of measured data (RSR)

$$NSE = 1 - \left[\frac{\sum_{i=1}^{n} (Y_i^{obs} - Y_i^{sim})^2}{\sum_{i=1}^{n} (Y_i^{obs} - Y^{mean})^2} \right] \quad \text{(S1)}$$

$$PBIAS = \left[\frac{\sum_{i=1}^{n} (Y_i^{obs} - Y_i^{sim}) \times 100}{\sum_{i=1}^{n} (Y_i^{obs})} \right] \quad \text{(S2)}$$

$$RSR = \frac{RMSE}{STD_{obs}} = \frac{\sqrt{\sum_{i=1}^{n} (Y_i^{obs} - Y_i^{sim})^2}}{\sqrt{\sum_{i=1}^{n} (Y_i^{obs} - Y^{mean})^2}} \quad \text{(S3)}$$

where Y_i^{obs} is the *i*th observation for the constituent being evaluated (spatially-averaged monthly mean temperature and precipitation from weather stations), Y_i^{sim} is the *i*th simulated value for the constituent being evaluated (NLDAS), Y^{mean} is the mean of the observed data for the constituent being evaluated, and n is the total number of observations, $RMSE$ is the root mean square error, and STD_{obs} is the standard deviation of the observation.

Man-Kendall, Seasonal Man-Kendall, Sen's Slope, and Pettitt's test

For annual data, we performed standard Mann-Kendall test using following equations:

$$\alpha^2 = \left\{ n(n-1)(2n+5) - \sum_{j=1}^{p} t_j (t_j - 1)(2t_j + 5) \right\} / 18 \quad \text{(S4)}$$

with

$$\operatorname{sgn}(x)=\begin{cases} 1 & if \quad x>0 \\ 0 & if \quad x=0 \\ -1 & if \quad x<0 \end{cases} \qquad \text{(S5)}$$

The mean of S is $E[S]=0$ and the variance α^2 is

$$D=\left[\frac{1}{2}n(n-1)-\frac{1}{2}\sum_{j=1}^{p}t_j(t_j-1)\right]^{1/2}\left[\frac{1}{2}n(n-1)\right]^{1/2} \qquad \text{(S6)}$$

where p is the number of the tied groups in the data set and t_j is the number of data points in the jth tied group. The statistic S is closely related to Kendall's τ as given by:

$$\tau=\frac{S}{D} \qquad \text{(S7)}$$

where

$$D=\left[\frac{1}{2}n(n-1)-\frac{1}{2}\sum_{j=1}^{p}t_j(t_j-1)\right]^{1/2}\left[\frac{1}{2}n(n-1)\right]^{1/2} \qquad \text{(S8)}$$

We calculated Sen's Slope (Sen, 1968) for linear rate of change and the corresponding intercept as this method is robust to outliers using the following equations:

$$d_k=\frac{X_j-X_i}{j-i} \qquad \text{(S9)}$$

for $(1 \le i \le j \le n)$, where d is the slope, X denotes the variable, n is the number of data, and i,j are indices. Sen's slope was then calculated as the median from all slopes: b = Median d_k. The intercepts are computed for each time step t as given by

$$\alpha_t = X_t - b * t \qquad \text{(S10)}$$

We also performed Pettitt's test (Pettitt, 1979) to detect potential change-point and catch the nonlinear trend in a time series using the following equations:

$$K_t = \max\left|U_{t,T}\right| \qquad \text{(S11)}$$

where

$$U_{t,T} = \sum_{i=1}^{t}\sum_{j=t+1}^{T} \operatorname{sgn}(x_i - X_j) \qquad \text{(S12)}$$

The change-point of the series is located at K_T, provided that the statistics is significant. The significance probability of K_T is approximated for $p \le 0.05$ with

$$p \cong 2\exp\left(\frac{-6K_T^2}{T^3 + T^2}\right) \qquad \text{(S13)}$$

As the climate and hydrological variables of the three basins in general exhibited a similar trend over the period of 1985-2014, we also grouped them together and preformed trend and change-point analysis on a regional scale.

For monthly data, we performed seasonal Mann-Kendall test (Hipel and McLeod 2005; Libiseller and Grimvall, 2002) to minimize data seasonality. The Mann-Kendall statistic for the gth season is calculated as:

$$S_g = \sum_{i=1}^{n-1}\sum_{j=i+1}^{n} \operatorname{sgn}(X_{jg} - X_{ig}), g = 1, 2, ..., m \qquad \text{(S14)}$$

The seasonal Mann-Kendall statistics, $\hat{S}$, for the entire series is calculated according to

$$\hat{S} = \sum_{g=1}^{m} S_g \qquad \text{(S15)}$$

Continuous wavelet transform (CWT) and wavelet coherence analysis (TWC)

The approach used in wavelet power spectra computation is the Morlet wavelet as following:

$$\psi_o(\eta) = \pi^{-\frac{1}{4}} e^{i\omega_o \eta} e^{-\frac{\eta^2}{2}} \qquad \text{(S16)}$$

where $\psi_o(\eta)$ is the wavelet function, η is a dimensionless time parameter, *i* is the imaginary unit, and ω_o is dimensionless angular frequency, which provides a balance between time and frequency localization. For a time series X_n for each scale s at all *n* of series length *N*, the wavelet function is represented as:

$$W_n(s) = \frac{1}{N}\sum_{n'=0}^{N-1} x_{n'}\psi * \left[\frac{(\eta' - \eta)\Delta t}{s}\right] \qquad \text{(S17)}$$

where $W_n(s)$ is the wavelet transform coefficient, ψ is the normalized wavelet, (*) is the complex conjugate, *s* is the wavelet scale, *n* is the localized time index, and *n′* is the translated time index of the time ordinate *x*.

For wavelet coherence, the computation is analogous to the correlation coefficient between two series X and Y with wavelet transforms $W_n^X(s)$ and $W_n^Y(s)$ is defined as:

$$R_n^2(s) = \frac{\left|S(s^{-1}W_n^{XY}(s))\right|^2}{S(s^{-1}\left|W_n^X(s)\right|^2) \times S(s^{-1}\left|W_n^Y(s)\right|^2)} \qquad \text{(S18)}$$

where *S* is a smoothing operator both in the scale axis and time domain.

$$S(W) = S_{scale}(S_{time}(W_n(s))) \qquad \text{(S19)}$$

where S_{time} smooths along the time axis and S_{scale} along the scale axis.