



Supplement of

Signatures of human intervention – or not? Downstream intensification of hydrological drought along a large Central Asian river: the individual roles of climate variability and land use change

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Reservoirs	Water balance equations	5	Constructive equations	
Snow	$\frac{dS_{sn}}{dt} = P_s - M$	(1)	$P_s = \begin{cases} P; & T < T_t \\ 0; & T \ge T_t \end{cases}$	(2)
			$M = \begin{cases} 0, & T < T_t \\ \min\left(F_{dd} (T - T_t), \frac{s_{sn}}{dt}\right), & T \ge T_t \end{cases}$	(3)
Interception	$\frac{dS_i}{dt} = P_r + M - P_e - E_i$	(4)	$P_r = \begin{cases} 0; & T < T_t \\ P; & T \ge T_t \end{cases}$	(5)
			$P_e = \max(0, \frac{S_i - I_{max}}{dt})$	(6)
			$E_i = \min(E_P, \frac{S_i - P_e}{dt})$	(7)
Insaturated reservoir	$\frac{dS_u}{dt} = P_e(1 - C_r) - R_s - E_T$	(8)	$Cr = 1 - \left(1 - \frac{s_u}{s_{u,max}(1+\beta)}\right)^{\beta}$	(9)
			$R_s = \min(P_{max}\left(\frac{s_u}{s_{u,max}}\right), \frac{s_u}{dt})$	(10)
			$E_T = \min((E_0 - E_i) \min\left(\frac{S_u}{S_{u,max}C_e}, 1\right), \frac{S_u}{dt})$	(11)
			$R_f = P_e C_r$	(12)
Fast reservoir	$\frac{ds_f}{dt} = R_f - Q_f$	(13)	$Q_f = S_f K_f$	(14)
Slow reservoir	$\frac{dS_s}{dt} = R_s - Q_s$	(15)	$Q_s = S_s K_s$	(16)
			$Q = (1 - K_L)(Q_f + Q_s)$	(17)



Figure S1. Cumulative gamma distribution function (CDF) of 12-month aggregated precipitation to estimate SPI in each month in the HRB. The red line and blue dots indicate the fitted and empirical gamma CDF, respectively.



Figure S2. Generalized extreme value (GEV) cumulative distribution of moisture deficit (Precipitation-Evapotranspiration) to estimate SPEI in each month in the HRB. The red line and blue dots indicate the fitted and empirical GEV, respectively.



Figure S3. Cumulative gamma distribution function (CDF) of 12-month aggregated streamflow to estimate SDI in each month in the HRB. The red line and blue dots indicate the fitted and empirical gamma CDF, respectively.



Figure S4. Sensitivity analysis of the effects of uncertainties in the low flow reservoir routing scheme on downstream flow of HRB. The blue dots show the average root mean square error (RMSE) of reproduced flow downstream of Kajakai dam by using various percentiles of the confidence interval of the reservoir low flow storage-discharge equation.



Figure S5. Precipitation and streamflow in UARB_U (ID4), UARB_D (ID5) and LARB (ID6). The purple bars show the modelled snowfall P_S [mm d⁻¹], the dark blue bars the modelled snowmelt M [mm d⁻¹] and the light blue bars the modelled rainfall P_R [mm d⁻¹]. The dashed black lines indicate the observed runoff and the shaded areas the uncertainty ranges of modelled runoff during calibration, validation and prediction periods.



Figure S6. Distributions of the mean basin (a) SPI, (b) SPEI and (c) SDI over the study period. The dots in the box plots indicate the median values and the whiskers the 5/95th percentiles.