



**FIGURE 2** Elder Creek model wiring diagram.

**TABLE 1** Elder Creek model state variables. All state variables have units of mm.

state variable	description
$S_s$	soil moisture storage
$S_r$	unsaturated fractured rock storage
$S_{g,lin}$	linear groundwater reservoir storage
$S_{g,nonlin}$	nonlinear groundwater reservoir storage

**TABLE 2** Elder Creek model fluxes. All fluxes have units of mm/h.

flux	description	type
P	precipitation	external
ETP	total potential evapotranspiration	external
ETA <sub>s</sub>	actual evapotranspiration from the soil	external
ETA <sub>r</sub>	actual evapotranspiration from the unsaturated fractured rock	external
q <sub>lin</sub>	discharge from the linear groundwater reservoir	external
q <sub>nonlin</sub>	discharge from the nonlinear groundwater reservoir	external
f <sub>sr</sub>	overflow leakage from soil to unsaturated fractured rock	internal
f <sub>gd</sub>	gravity drainage from unsaturated fractured rock to groundwater	internal
f <sub>rg</sub>	overflow leakage from unsaturated fractured rock to groundwater	internal
f <sub>g</sub>	flow from linear to nonlinear groundwater reservoir	internal

**TABLE 3** Elder creek model parameters.\*\*\*Note: three parameters here have different names than in the code, for the purpose of code clarity:  $s_{wilt}$  in this manuscript represents  $\theta_{wilt}$  in the code,  $k_{sat}$  in this manuscript represents  $k_{fc}$  in the code, and  $r$  in this manuscript represents  $f$  in the code. This is explained in the code.\*\*\*

parameter	units	description	calibration range
$r$	-	relative root density; controls distribution of ET between soil and unsaturated rock stores	0.001 - 1
$S_{s,max}$	mm	maximum soil water storage; controls threshold at which soil leakage begins, as well as correction of ET	1 - 1000
$S_{r,max}$	mm	maximum unsaturated rock water storage; controls threshold at which leakage to groundwater begins, rate of gravity drainage from unsaturated rock to groundwater, and correction of ET	500 - 20000
$s_{wilt}$	-	relative moisture of $S_{r,max}$ and $S_{s,max}$ below which no actual evapotranspiration comes from the unsaturated rock	0 - 0.5
$b_{fc}$	-	power controlling shape of gravity drainage from unsaturated rock to groundwater	1 - 40
$k_{sat}$	mm h <sup>-1</sup>	saturated hydraulic conductivity of fractured rock, which controls rate of gravity drainage to groundwater	4 - 1000
$a$	h <sup>-1</sup> (mm) <sup>1-b</sup>	coefficient for nonlinear groundwater reservoir	5e-5 - 0.125
$b$	-	exponent for nonlinear groundwater reservoir	0.5 - 3
$k_1$	h <sup>-1</sup>	coefficient which controls the discharge of the linear groundwater reservoir	5e-5 - 0.125
$k_{12}$	h <sup>-1</sup>	linear groundwater reservoir coefficient which controls the rate at which water flows from the linear saturated store to the nonlinear saturated store	5e-5 - 0.125

$$\frac{\Delta S_s}{\Delta t} = P - \text{ETA}_s - f_{sr} \quad (1)$$

$$\text{ETA}_s = \frac{S_s - S_{s,max} \cdot s_{wilt}}{S_{s,max}} \cdot \frac{1}{1 - s_{wilt}} \cdot r \cdot \text{ETP} \quad (2)$$

$$f_{sr} = \begin{cases} (S_s + (P - \text{ETA}_s) \cdot \Delta t - S_{s,max}) / \Delta t & \text{if } S_s + (P - \text{ETA}_s) \cdot \Delta t > S_{s,max} \\ 0 & \text{if } S_s + (P - \text{ETA}_s) \cdot \Delta t \leq S_{s,max} \end{cases} \quad (3)$$

$$\frac{\Delta S_r}{\Delta t} = f_{sr} - f_{rg} - f_{gd} - \text{ETA}_r \quad (4)$$

$$\text{ETA}_r = \max(0, \frac{S_r - S_{r,max} \cdot s_{wilt}}{S_{r,max}} \cdot \frac{1}{1 - s_{wilt}} \cdot (1 - r) \cdot \text{ETP}) \quad (5)$$

$$f_{gd} = k_{sat} \cdot (S_r / S_{r,max})^{b_{fc}} \quad (6)$$

$$f_{rg} = \begin{cases} (S_r + (f_{sr} - \text{ETA}_r - f_{gd}) \cdot \Delta t - S_{r,max}) / \Delta t & \text{if } S_r + (f_{sr} - \text{ETA}_r - f_{gd}) \cdot \Delta t > S_{r,max} \\ 0 & \text{if } S_r + (f_{sr} - \text{ETA}_r - f_{gd}) \cdot \Delta t \leq S_{r,max} \end{cases} \quad (7)$$

$$\frac{\Delta S_{g,lin}}{\Delta t} = f_{gd} + f_{rg} - q_{lin} - f_g \quad (8)$$

$$q_{lin} = k_1 \cdot S_{g,lin} \quad (9)$$

$$f_g = k_{12} \cdot S_{g,lin} \quad (10)$$

$$\frac{\Delta S_{g,nonlin}}{\Delta t} = f_g - q_{nonlin} \quad (11)$$

$$q_{nonlin} = a \cdot (S_{g,nonlin})^b \quad (12)$$