Development and evaluation of an ecohydrology soi-moisture model to aid in understanding semi-arid ecosystem dynamics – Supplementary Material

Eq.#	Variable (type)	Equation	Initial value; Units
1	Biomass (stock)	= Biomass(t - dt) + (Plant_ET_b - Plant_loss)	3; 100 kg
2	Plant ET b (flow)	= soil_moisture_effected_ET_over_reference_ET*Biomass_effect_on_ET	kg/day
3	Plant loss (flow)	= (DELAY(Plant_ET_b, Senescence_rate))+(Active_grazing_losses*Biomass)	kg/day
4	model_rainfall_guage (stock)	= model_rainfall_guage(t - dt) + (model_rainfall__per_sim)	0; cm
5	model_rainfall__per_sim (flow)	= Precip_data_used	cm/day
6	Rainfall_per_year[Location](stock)	= Rainfall_per_year[Location](t - dt) + (Rainfall_over_time[Location])	0; cm
7	Rainfall_over_time[Edin] (flow)	= Edin_cm	cm/day
8	Rainfall_over_time[Freeman] (flow)	= Freeman_cm	cm/day
9	Rainfall_over_time[Palest] (flow)	= Palest_cm	cm/day
10	Rainfall_over_time[Seymour] (flow)	= Symr_cm	cm/day
11	Rainfall_over_time[Model_generated] (flow)	= Rainfall	cm/day
12	Soil_H2O (stock)	= Infiltration - ET_losses - Percolation_or_runoff_losses	initial_s_by_scenario ; cm
14	Infiltration (flow)	= model_rainfall__per_sim*((100-Canopy__interseption)/100)-Runoff	cm/day
15	ET_losses (flow)	= Soil__evaporation+Soil_moisture__effected_ET	cm/day
16	Percolation_or_runoff_losses (flow)	= IF Percolation_or__runoff_rate>0 THEN Percolation_or__runoff_rate ELSE 0	cm/day
17	Active_grazing_losses (auxiliary)	= IF TIME>Grazing_day_start_time AND TIME<Grazing_day_end_time THEN Grazing_volume__percentage*Grazing__frequency ELSE 0	kg/day
18	applied_reference_ET (auxiliary)	= ET_reference_in_cm*weighted_average_k	cm/day
19	average_rainfall__depth_a (constant)	= 0.4	cm
20	Canopy__interseption (auxiliary)	= Rainfall_canopy__interseption_slope*((100-Biomass_effect__on_soil_cover)/100)	cm/day
21	Depth_z (constant)	= 90	cm
22	EDIN_latitude (constant)	= 26.5258	degrees
23	Estimated_grazing_days (auxiliary)	= 0	days
24	ET_reference_in_cm (auxiliary)	= ((0.0023*(incoming_solar_radiation*((T_mean)+17.8))*(Temperature_range^0.5))/10)	cm/day

25	ET_wilting (auxiliary)	= 0.01	cm
26	EvapoTranspiration (flow)	= Soil__evaporation+Soil_moisture__effected_ET	cm/day
27	fc_clay (constant)	= 0.99	Dmnl, field capacity of open pore space
28	fc_devl (constant)	= 0.56	Dmnl, field capacity of open pore space
29	fc_loam (constant)	= 0.65	Dmnl, field capacity of open pore space
30	fc_loamy_sand (constant)	= 0.52	Dmnl, field capacity of open pore space
31	fc_sandy_loam (constant)	= 0.56	Dmnl, field capacity of open pore space
32	Forage_life_in_months (constant)	= 4	months
33	FRRA_latitude (constant)	= 29.9495	degrees
34	grass_crop_coefficient (constant)	= 1	Dmnl, crop coefficient used for potential ET estimation
35	brush_crop_coefficient (constant)	= 0.8	Dmnl, crop coefficient used for potential ET estimation
36	Grazing_day_end_time (auxiliary)	= Grazing_day_start_time+Estimated_grazing_days	days
37	Grazing_day_start_time (auxiliary)	= 120	days
38	Grazing_volume__percentage (constant)	Range from 0.0033 – 0.5	Dmnl, percentage of biomass removed per day
39	Grazing__frequency (constant)	= 1	Grazing events per day of grazing
40	incoming_solar_radiation (auxiliary)	=15.392*Ratio_of_actual_to_mean_Earth_Sun_distance*((sunset_hour_angle*SIN(latitude_in_radians)*SIN(solar_declination_angle))+(COS(latitude_in_radians)*COS(solar_declination_angle)*SIN(sunset_hour_angle)))	Radians
41	initial_s_by_scenario (auxiliary)	= IF Soil_setting=1 THEN initial_s_loamy_sand ELSE IF Soil_setting=2 THEN initial_s_sandy_loam ELSE IF Soil_setting=3 THEN initial_s_loam ELSE IF Soil_setting=4 THEN initial_s_clay ELSE initial_s_devl	cm
42	initial_s_clay (auxiliary)	= 1.5	cm
43	initial_s_devl (auxiliary)	= 7	cm
44	initial_s_loam (auxiliary)	= 3.7	cm

45	initial_s_loamy_sand (auxiliary)	= 6.5	cm
46	initial_s_sandy_loam (auxiliary)	= 2.6	cm
47	Julian_days (auxiliary)	= COUNTER(1,365)	days
48	Latitude (constant)	= latitude_by_scenario	degree
49	latitude_by_scenario (auxiliary)	= IF Location_setting=1 THEN EDIN_latitude ELSE IF Location_setting=2 THEN FRRA_latitude ELSE IF Location_setting=3 THEN PLST_latitude ELSE IF Location_setting=4 THEN SYMR_latitude ELSE latitude_devl	degree
50	latitude_devl (auxiliary)	= 33.63	degree
51	latitude_in_radians (auxiliary)	= Latitude*(3.141592/180)	radians
52	Location_setting (constant)	= 0	Dmnl, scenario setting variable
53	Mean_LAI (constant)	= 2.5	Dmnl
54	mean_rainfall_depth_normalized_to_active_soil_depth (auxililary)	= average_rainfall__depth_a/Total_soil__water_potential	Dmnl
55	n_clay (constant)	= 0.5	Dmnl, porosity of soil column
56	n_devl (constant)	= 0.43	Dmnl, porosity of soil column
57	n_loam (constant)	= 0.45	Dmnl, porosity of soil column
58	n_loamy_sand (constant)	= 0.42	Dmnl, porosity of soil column
59	n_sandy_loam (constant)	= 0.43	Dmnl, porosity of soil column
60	Percentage_of__Field_Capacity (auxiliary)	= Soil_H2O/Total_soil__water_potential	Dmnl
61	Porosity_n (constant)	= porosity_n_by_scenario	Dmnl, porosity of soil column
62	porosity_n_by_scenario (auxiliary)	= IF Soil_setting=1 THEN n_loamy_sand ELSE IF Soil_setting=2 THEN n_sandy_loam ELSE IF Soil_setting=3 THEN n_loam ELSE IF Soil_setting=4 THEN n_clay ELSE n_devl	Dmnl, porosity of soil column
63	Precip_data_used (auxiliary)	= IF Location_setting=1 THEN Edin_cm ELSE IF Location_setting=2 THEN Freeman_cm ELSE IF Location_setting=3 THEN Palest_cm ELSE IF Location_setting=4 THEN Symr_cm ELSE Rainfall	cm
64	Proportion_of_grasses (auxiliary)	= 1-proportion_of_schrub_brush	Dmnl
65	proportion_of_schrub_brush (auxiliary)	= 0	Dmnl
66	Rainfall (auxiliary)	= Rainfall__events*Rainfall__depths_h	cm/day

67	rainfall_depth__of_event_h (auxiliary)	= RANDOM(0.25,1.25, rain_depth_seed)	cm
68	rainfall_gamma (auxiliary)	= 1/mean_rainfall_depth_normalized_to_active_soil_depth	Dmnl
69	Rainfall__depths_h (auxiliary)	= (1/average_rainfall__depth_a)*EXP(rainfall_depth__of_event_h/average_rainfall__depth_a)	cm
70	Rainfall__events (auxiliary)	= POISSON(1/21, rain_event_seed)	Dmnl
71	rain_depth_seed (constant)	= 10348	Dmnl
72	rain_event_seed (constant)	= 28954	Dmnl
73	Ratio_of_actual_to_mean_Earth_Sun_distance (auxiliary)	= 1+0.033*COS((2*3.14159*Julian_days)/365)	Dmnl
74	Runoff (auxiliary)	= IF Percentage_of__Field_Capacity>=1 THEN model_rainfall__per_sim ELSE model_rainfall__per_sim*(Mean_LAI_effect__on_runoff/100)	cm/day
75	Senescence_rate (auxiliary)	= Forage_life_in_months*30.4	kg/day
76	Soil_evapo_ration_rate (auxiliary)	= 0.05	cm/day
77	soil_moisture_effected_ET_over_reference_ET (auxiliary)	= Soil_moisture__effected_ET/ET_reference_in_cm	Dmnl
78	Soil_moisture_effect_on_leaf_conductance (auxiliary)	= ET_wilting+(applied_reference_ET-ET_wilting)*(Percentage_of__Field_Capacity-s_wilting)/(s_star-s_wilting)	cm/day
79	Soil_moisture_effect_on_plant_shutdown (auxiliary)	= ET_wilting*(Percentage_of__Field_Capacity-s_hydroscopic)/(s_wilting-s_hydroscopic)*applied_reference_ET	cm/day
80	Soil_moisture__effected_ET (auxiliary)	= IF(s_star<Percentage_of__Field_Capacity) THEN applied_reference_ET ELSE (IF(s_wilting<Percentage_of__Field_Capacity AND Percentage_of__Field_Capacity<s_star) THEN (Soil_moisture_effect_on_leaf_conductance) ELSE (IF(s_hydroscopic<Percentage_of__Field_Capacity AND Percentage_of__Field_Capacity<s_wilting) THEN (Soil_moisture_effect_on_plant_shutdown) ELSE 0))	cm/day
81	Soil_setting (constant)	= 0	Dmnl, scenario setting variable
82	Soil__evaporation (auxiliary)	= IF(Percentage_of__Field_Capacity<1) THEN Soil_evapo_ration_rate ELSE 0	cm/day

83	solar_declination_angle (auxiliary)	= 0.4093*SIN(((2*3.141592*Julian_days)/365)-1.405)	Dmnl
84	sunset_hour_angle (auxiliary)	= ARCCOS(-TAN(latitude_in_radians)*TAN(solar_declination_angle))	Dmnl
85	SYMR_latitude (constant)	= 33.63233	degrees
86	s_fc (auxiliary)	= s_fc_by_scenario	Dmnl
87	s_fc_by_scenario (auxiliary)	= IF Soil_setting=1 THEN fc_loamy_sand ELSE IF Soil_setting=2 THEN fc_sandy_loam ELSE IF Soil_setting=3 THEN fc_loam ELSE IF Soil_setting=4 THEN fc_clay ELSE fc_devl	Dmnl
88	s_hydroscopic (auxiliary)	= s_hydroscopic_by_scenario	Dmnl
89	s_hydroscopic_by_scenario (auxiliary)	= IF Soil_setting=1 THEN s_h_loamy_sand ELSE IF Soil_setting=2 THEN s_h_sandy_loam ELSE IF Soil_setting=3 THEN s_h_loam ELSE IF Soil_setting=4 THEN s_h_clay ELSE s_h_devl	Dmnl
90	s_h_clay (constant)	= 0.47	Dmnl
91	s_h_devl (constant)	= 0.14	Dmnl
92	s_h_loam (constant)	= 0.19	Dmnl
93	s_h_loamy_sand (constant)	= 0.08	Dmnl
94	s_h_sandy_loam (constant)	= 0.14	Dmnl
95	s_star (auxiliary)	= s_star_by_scenario	Dmnl
96	s_star_by_scenario (auxiliary)	= IF Soil_setting=1 THEN s_star_loamy_sand ELSE IF Soil_setting=2 THEN s_star_sandy_loam ELSE IF Soil_setting=3 THEN s_star_loam ELSE IF Soil_setting=4 THEN s_star_clay ELSE s_star_devl	Dmnl
97	s_star_clay (constant)	= 0.78	Dmnl
98	s_star_devl (constant)	= 0.46	Dmnl
99	s_star_loam (constant)	= 0.57	Dmnl
100	s_star_loamy_sand (constant)	= 0.31	Dmnl
101	s_star_sandy_loam (constant)	= 0.46	Dmnl
102	s_wilting (auxiliary)	= s_wilt_by_scenario	Dmnl

103	s_wilt_by_scenario (auxiliary)	= IF Soil_setting=1 THEN s_wilt_loamy_sand ELSE IF Soil_setting=2 THEN s_wilt_sandy_loam ELSE IF Soil_setting=3 THEN s_wilt_loam ELSE IF Soil_setting=4 THEN s_wilt_clay ELSE s_wilt_devl	Dmnl
104	s_wilt_clay (constant)	= 0.52	Dmnl
105	s_wilt_devl (constant)	= 0.18	Dmnl
106	s_wilt_loam (constant)	= 0.24	Dmnl
107	s_wilt_loamy_sand (constant)	= 0.11	Dmnl
108	s_wilt_sandy_loam (constant)	= 0.18	Dmnl
109	Temperature_range (auxiliary)	= Tmax-Tmin	degrees C
110	Total_soil__water_potential (auxiliary)	= (Depth_Z*Porosity_n)*s_fc	cm
111	t_max_by_scenario (auxiliary)	= IF Location_setting=1 THEN t_max_EDIN ELSE IF Location_setting=2 THEN t_max_FRRA ELSE IF Location_setting=3 THEN t_max_PLST ELSE IF Location_setting=4 THEN t_max_SYMR ELSE t_max_devl	Dmnl
112	t_mean_by_scenario (auxiliary)	= IF Location_setting=1 THEN t_mean_EDIN ELSE IF Location_setting=2 THEN t_mean_FRRA ELSE IF Location_setting=3 THEN t_mean_PLST ELSE IF Location_setting=4 THEN t_mean_SYMR ELSE t_mean_devl	Dmnl
113	t_min_by_scenario (auxiliary)	= IF Location_setting=1 THEN t_min_EDIN ELSE IF Location_setting=2 THEN t_min_FRRA ELSE IF Location_setting=3 THEN t_min_PLST ELSE IF Location_setting=4 THEN t_min_SYMR ELSE t_min_devl	Dmnl
114	weighted_average_k (auxiliary)	=(Proportion_of_grasses*grass_crop_coefficient)+(proportion_of_schrub_brush*brush_crop_coefficient)	Dmnl
115	Biomass_effect_on_ET (auxiliary)	= GRAPH(Biomass) (0.00, 1.00), (12.5, 1.15), (25.0, 1.29), (37.5, 1.40), (50.0, 1.41)	Dmnl
116	Biomass_effect__on_LAI (auxiliary)	See Table 2.	Dmnl
117	Biomass_effect__on_soil_cover (auxiliary)	See Table 2.	Dmnl
118	Mean_LAI_effect__on_runoff (auxiliary)	= GRAPH((Mean_LAI+Biomass_effect__on_LAI)/2) (0.00, 100), (1.25, 22.5), (2.50, 5.00), (3.75, 1.50), (5.00, 0.00)	Dmnl
119	Percolation_or__runoff_rate (flow)	= GRAPH(Percentage_of__Field_Capacity) (0.00, 0.00), (0.09, 0.00), (0.18, 0.00), (0.27, 0.00), (0.36, 0.00), (0.45, 0.00), (0.54, 0.00), (0.63, 0.00), (0.72, 0.21), (0.81, 0.81), (0.9, 3.00)	cm/day

120	Rainfall_canopy__interception_slope (auxiliary)	= GRAPH(model_rainfall__per_sim) (0.00, 98.0), (0.111, 20.0), (0.222, 7.00), (0.333, 6.00), (0.444, 5.00), (0.556, 4.50), (0.667, 3.00), (0.778, 2.00), (0.889, 0.3), (1.00, 0.00)	Dmnl
121	PLST_latitude(constant)	= 31.7796	degrees
122	t_max_devl (auxiliary)	= GRAPH(TIME) (0.00, 16.0), (33.2, 19.0), (66.4, 23.0), (99.5, 26.0), (133, 29.0), (166, 33.0), (199, 36.0), (232, 36.0), (265, 33.0), (299, 28.0), (332, 22.0), (365, 17.0)	degrees C
123	t_max_EDIN (auxiliary)	= GRAPH(TIME) (0.00, 21.1), (33.2, 23.3), (66.4, 26.7), (99.5, 29.4), (133, 32.2), (166, 34.4), (199, 35.6), (232, 36.1), (265, 33.9), (299, 30.6), (332, 26.1), (365, 21.7)	degrees C
124	t_max_FRRA (auxiliary)	= GRAPH(TIME) (0.00, 16.7), (33.2, 18.9), (66.4, 22.8), (99.5, 26.7), (133, 30.0), (166, 32.8), (199, 34.4), (232, 35.6), (265, 32.2), (299, 27.8), (332, 22.2), (365, 17.2)	degrees C
125	t_max_PLST (auxiliary)	= GRAPH(TIME) (0.00, 13.9), (33.2, 16.1), (66.4, 20.0), (99.5, 24.4), (133, 27.8), (166, 31.1), (199, 33.3), (232, 34.4), (265, 30.6), (299, 25.6), (332, 19.4), (365, 15.0)	degrees C
126	t_max_SYMR (auxiliary)	= GRAPH(TIME) (0.00, 12.2), (33.2, 14.4), (66.4, 19.4), (99.5, 24.4), (133, 28.9), (166, 33.3), (199, 36.1), (232, 35.6), (265, 31.1), (299, 25.6), (332, 18.3), (365, 12.2)	degrees C
127	t_mean_devl (auxiliary)	= GRAPH(TIME) (0.00, 10.0), (33.2, 13.0), (66.4, 16.5), (99.5, 20.0), (133, 23.5), (166, 27.5), (199, 29.5), (232, 29.5), (265, 27.0), (299, 21.5), (332, 15.5), (365, 11.5)	degrees C
128	t_mean_EDIN (auxiliary)	= GRAPH(TIME) (0.00, 15.0), (33.2, 16.9), (66.4, 20.3), (99.5, 23.6), (133, 26.7), (166, 29.2), (199, 29.7), (232, 30.3), (265, 28.3), (299, 24.4), (332, 19.7), (365, 15.6)	degrees C
129	t_mean_FRRA (auxiliary)	= GRAPH(TIME) (0.00, 10.3), (33.2, 12.2), (66.4, 16.1), (99.5, 20.3), (133, 24.2), (166, 27.5), (199, 28.9), (232, 29.4), (265, 26.1), (299, 21.1), (332, 15.8), (365, 10.8)	degrees C
130	t_mean_PLST (auxiliary)	= GRAPH(TIME) (0.00, 7.78), (33.2, 9.72), (66.4, 13.6), (99.5, 18.1), (133, 22.2), (166, 25.8), (199, 27.8), (232, 28.1), (265, 24.2), (299, 18.9), (332, 13.1), (365, 8.61)	degrees C
131	t_mean_SYMR (auxiliary)	= GRAPH(TIME)	degrees C

		(0.00, 5.00), (33.2, 6.94), (66.4, 11.9), (99.5, 16.7), (133, 22.2), (166, 26.7), (199, 29.2), (232, 28.6), (265, 23.9), (299, 18.1), (332, 11.1), (365, 5.28)	
132	t_min_devl (auxiliary)	= GRAPH(TIME) (0.00, 4.00), (33.2, 7.00), (66.4, 10.0), (99.5, 14.0), (133, 18.0), (166, 22.0), (199, 23.0), (232, 23.0), (265, 21.0), (299, 15.0), (332, 9.00), (365, 6.00)	degrees C
133	t_min_EDIN (auxiliary)	= GRAPH(TIME) (0.00, 8.89), (33.2, 10.6), (66.4, 13.9), (99.5, 17.8), (133, 21.1), (166, 23.9), (199, 23.9), (232, 24.4), (265, 22.8), (299, 18.3), (332, 13.3), (365, 9.44)	degrees C
134	t_min_FRRA (auxiliary)	= GRAPH(TIME) (0.00, 3.89), (33.2, 5.56), (66.4, 9.44), (99.5, 13.9), (133, 18.3), (166, 22.2), (199, 23.3), (232, 23.3), (265, 20.0), (299, 14.4), (332, 9.44), (365, 4.44)	degrees C
135	t_min_PLST (auxiliary)	= GRAPH(TIME) (0.00, 1.67), (33.2, 3.33), (66.4, 7.22), (99.5, 11.7), (133, 16.7), (166, 20.6), (199, 22.2), (232, 21.7), (265, 17.8), (299, 12.2), (332, 6.67), (365, 2.22)	degrees C
136	t_min_SYMR (auxiliary)	= GRAPH(TIME) (0.00, -2.22), (33.2, -0.556), (66.4, 4.44), (99.5, 8.89), (133, 15.6), (166, 20.0), (199, 22.2), (232, 21.7), (265, 16.7), (299, 10.6), (332, 3.89), (365, -1.67)	degrees C