



Supplement of

Modelling groundwater recharge, actual evaporation, and transpiration in semi-arid sites of the Lake Chad basin: the role of soil and vegetation in groundwater recharge

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Table S1: Precipitation chloride concentration measured in N'Djamena.

Sampling Date	Precipitation amount (mm)	Chloride concentration (mg l ⁻¹)
16/06/2016	19	1.25
17/06/2016	17	0.82
26/06/2016	20	0.37
12/07/2016	55	0.13
25/07/2016	0.5	0.37
01/08/2016	51	0.29
07/08/2016	13.5	0.17
10/08/2016	23	0.22
24/08/2016	29	0.22
01/09/2016	36	0.20
24/05/2017	1	19.60
30/05/2017	4	3.40
10/06/2017	1	3.24
12/06/2017	12	0.82
21/06/2017	33	1.45
22/06/2017	8	1.12
27/06/2017	11	0.97
30/06/2017	6	0.53
05/07/2017	40	0.39
08/07/2017	30	0.17
17/07/2017	24	0.19
24/07/2017	65	0.15
09/08/2017	55	0.15
15/08/2017	23	0.28
18/08/2017	40	0.17
14/09/2017	29	0.31
25/09/2017	31	0.43
28/05/2018	28	0.91
01/07/2018	60	0.16
07/07/2018	65	0.11
11/07/2018	46	0.16
13/07/2018	43	0.38
30/07/2018	50	0.09
08/08/2018	50	0.13
23/08/2018	80	0.05
07/09/2018	30	0.13
28/05/2019	45	1.89
30/05/2019	30	0.37
22/07/2019	121	0.17
05/08/2019	29	0.09
09/08/2019	45	0.08
27/08/2019	35	0.25
09/09/2019	45	0.46
15/09/2019	43	0.37
01/10/2019	36	0.55
04/10/2019	14	0.46

Sampling Date	Precipitation amount (mm)	Chloride concentration (mg l ⁻¹)
07/10/2019	20	0.27
04/05/2020	19.3	1.35
05/06/2020	15.9	1.30
09/06/2020	21.4	0.69
15/06/2020	26.5	0.29
19/06/2020	12	0.30
26/06/2020	14.4	0.85
05/07/2020	26.5	0.21
10/07/2020	27.4	0.18
14/07/2020	9.4	0.26
22/07/2020	13.2	0.16
24/07/2020	16.6	0.12
27/07/2020	24.6	0.15

Table S2: Soil chloride concentration measured in each of the Salamat profiles. GW (2016): chloride concentration in groundwater and year of measurement.

Site	Depth interval (cm)	Soil chloride concentration (mg l ⁻¹)		Gravimetric water content (%)	
		2016	2019	2016	2019
ST1	0-10	44.75	11.17	0.17	0.31
	10-20	42.14	15.05	0.18	0.18
	20-30	45.55	9.75	0.16	0.16
	30-40	29.40	7.07	0.28	0.20
	40-50	13.53	6.26	0.33	0.21
	50-60	32.15	3.82	0.34	0.23
	60-80	18.54	2.78	0.33	0.24
	80-100	12.26	2.64	0.28	0.24
	100-110	14.55	2.12	0.29	0.25
	110-120	24.89		0.29	
	120-130	29.28	1.72	0.28	0.23
	130-140	18.57		0.27	
	140-150	24.00	1.74	0.25	0.23
	150-160	55.14		0.27	
	160-170	51.84	1.91	0.22	0.23
	170-180	24.65		0.25	
	180-190	40.14	2.25	0.23	0.20
	190-200	28.30		0.22	
	200-210	42.37	15.5	0.22	0.20
	210-220	10.07		0.21	
	220-230	26.71	1.47	0.21	0.18
	230-240	24.25		0.22	
	240-260		1.75		0.16
	260-280		1.42		0.17
	280-300		1.26		0.16
	300-320		1.10		0.16
320-340		1.76		0.16	
340-360		2.23		0.14	
360-380		1.14		0.16	

Site	Depth interval (cm)	Soil chloride concentration (mg l ⁻¹)		Gravimetric water content (%)	
		2016	2019	2016	2019
	380-400		0.99		0.16
	400-420		1.41		0.16
	420-440		1.35		0.15
	440-460		1.38		0.16
	460-480		1.08		0.17
	480-500		1.02		0.18
GW (2019)	1,100	0.34			
ST2	0-10	269.66	21.07	0.03	0.25
	10-20	115.31	34.16	0.04	0.22
	20-30	82.18	134.77	0.05	0.18
	30-40	60.80	121.60	0.06	0.07
	40-50	98.79	40.65	0.09	0.08
	50-60	194.90	24.57	0.09	0.09
	60-70	210.85	28.27	0.06	0.08
	70-80	46.03		0.06	
	80-90	30.47	69.27	0.08	0.09
	90-100	36.89		0.08	
	100-110	37.52	160.93	0.08	0.10
	110-120	144.63		0.05	
	120-130	258.28	202.94	0.07	0.15
	130-140	233.81		0.17	
	140-150	304.90	206.61	0.16	0.20
	150-160	368.07		0.12	
	160-170	207.07	186.64	0.12	0.18
	170-180	158.34		0.13	
	180-190	191.84	146.81	0.12	0.14
	190-200	201.77		0.12	
	200-220		117.61		0.14
	220-240		82.31		0.14
	240-260		65.10		0.13
	260-280		48.25		0.13
	280-300		32.34		0.12
	300-320		25.89		0.12
	320-340		27.25		0.12
	340-360		26.81		0.12
	360-380		41.14		0.13
	380-400		49.37		0.14
	400-420		53.52		0.14
	420-440		56.65		0.14
	440-460		55.76		0.10
	460-480		101.40		0.01
	480-500		149.20		0.01
GW (2016)	1,700	1.39			
ST3	0-10	172.79	9.27	0.01	0.09
	10-20	73.81	15.44	0.02	0.08
	20-30	45.54	18.40	0.02	0.07
	30-40	37.08	8.65	0.03	0.06
	40-50	25.53	13.64	0.04	0.05
	50-60	10.71	6.38	0.08	0.05

Site	Depth interval (cm)	Soil chloride concentration (mg l ⁻¹)		Gravimetric water content (%)	
		2016	2019	2016	2019
	60-70	41.26		0.05	
	70-80	23.95	7.62	0.06	0.05
	80-90	30.15		0.07	
	90-100	15.67	6.12	0.08	0.07
	100-110	11.67		0.09	
	110-120	21.20	4.06	0.09	0.07
	120-130	54.53		0.10	
	130-140	19.90	6.48	0.10	0.06
	140-150	12.27		0.10	
	150-160	13.14	7.03	0.07	0.04
	160-170	16.54		0.05	
	170-180	15.62	11.41	0.04	0.04
	180-190	15.96		0.05	
	190-200	14.55	10.19	0.07	0.03
	200-210	7.40		0.08	
	210-220	14.77	8.93	0.10	0.08
	220-230	12.77		0.12	
	230-240	22.53	15.25	0.07	0.03
	240-250	101.22		0.03	
	250-260	80.82	7.08	0.03	0.03
	260-270	171.44		0.02	
	270-280	66.03	18.41	0.03	0.02
	280-300	88.52	11.64	0.02	0.02
	300-320		28.13		0.02
	320-340		24.83		0.01
	340-360		37.71		0.01
	360-380		30.59		0.02
	380-400		29.21		0.02
	400-420		32.63		0.02
	420-440		36.39		0.02
	440-460				
	460-480		39.34		0.02
	480-500		39.51		0.02
GW (2016)	2,100	4.10			

Table S3: Soil chloride concentration measured in each of the Waza Logone profiles in 2017. GW (2016): chloride concentration in groundwater and year of measurement.

Site	Depth interval (cm)	Soil chloride concentration (mg l ⁻¹)	Gravimetric water content (%)
WL1	0-10	246.74	0.12
	10-20	142.34	0.13
	20-30	39.42	0.12
	30-40	17.99	0.11
	40-50	18.03	0.07
	50-60	26.61	0.08
	60-70	9.44	0.11
	70-80	4.36	0.13
	80-90	8.31	0.15

Site	Depth interval (cm)	Soil chloride concentration (mg l ⁻¹)	Gravimetric water content (%)
	90-100	11.22	0.18
	100-120	7.33	0.16
	120-140	4.26	0.15
	140-160	3.65	0.16
	160-180	12.24	0.18
	180-200	3.11	0.19
	200-220	3.00	0.14
	220-240	7.18	0.11
	240-260	22.38	0.15
	260-280	18.40	0.14
	280-300	17.46	0.16
	300-320	16.14	0.17
	320-340	46.94	0.18
	340-360	24.16	0.17
	360-380	75.87	0.15
	380-400	6.86	0.15
GW (2017)	400	0.23	
WL2	0-10	446.21	0.03
	10-20	269.74	0.02
	20-30	106.04	0.04
	30-40	35.22	0.06
	40-50	44.11	0.06
	50-60	19.47	0.07
	60-80	18.40	0.08
	80-100	17.55	0.07
	100-120	15.36	0.06
	120-140	12.12	0.07
	140-160	101.76	0.07
	160-180	15.07	0.08
	180-200	5.86	0.09
	200-220	4.90	0.09
	220-240	3.85	0.09
	240-260	2.69	0.09
	260-280	2.73	0.10
	280-300	4.87	0.10
GW (2014)	1,200	0.90	
WL3	0-10	157.35	0.06
	10-20	50.59	0.09
	20-30	13.32	0.11
	30-40	32.41	0.11
	40-50	14.77	0.11
	50-60	9.02	0.12
	60-80	8.85	0.12
	80-100	10.27	0.13
	100-120	6.84	0.13
	120-140	6.28	0.13
	140-160	5.59	0.15
	160-180	7.63	0.20
	180-200	11.47	0.21
	200-220	4.83	0.19

Site	Depth interval (cm)	Soil chloride concentration (mg l ⁻¹)	Gravimetric water content (%)
	220-240	5.30	0.19
	240-260	4.74	0.21
	260-280	4.98	0.22
	280-300	9.54	0.23
	300-320	10.24	0.21
	320-340	9.75	0.22
	340-360	9.25	0.23
	360-380	21.78	0.17
GW (2017)	360	1.51	

Table S4: Site-specific estimated monthly variation of ground cover including grass, crops, and flooding periods with ranges of monthly basal crop coefficient (K_{cb}), soil water evaporation coefficient (K_e), and root depth used in the scenarios.

Location	Month	Vegetation	Kcb	Ke	Root depth (m)
ST1	Jan	Sorghum	1.01 – 0.86	0.12	1.5 – 2.5
	Feb	Sorghum	0.35 – 0.35	0.48	1.5 – 2.5
	Mar	Bare soil	0.0	0.47 – 0.68	0.0
	Apr	Bare soil	0.0	0.27 – 0.41	0.0
	May	Grass	0.6 – 0.4	0.1 – 0.12	0.1 – 0.5
	June	Grass	0.85 – 0.6	0.05	0.2 – 0.7
	July	Grass	1.03 – 0.83	0.12	0.2 – 0.7
	Aug	Flooded	0.3 – 0.2	0.9 – 1.0	0.2 – 0.7
	Sep	Flooded	0.0	1.08	0.0
	Oct	Flooded	0.0	1.08	0.0
	Nov	Sorghum	0.2 – 0.1	0.66	0.5 – 1.5
	Dec	Sorghum	1.01 – 0.86	0.12	1.5 – 2.5
ST2	Jan	Tree (Acacia)	0.5 – 0.8	0.2 – 0.34	Time invariant root distribution
	Feb	Tree	0.2 – 0.6	0.17 – 0.39	
	Mar	Tree	0.1 – 0.3	0.07 – 0.37	
	Apr	Tree	0.1 – 0.3	0.02 – 0.17	
	May	Tree, Grass	0.1 – 0.3	0.5	
	June	Tree, Grass	0.3 – 0.4	0.5	
	July	Tree, Grass	0.3 – 0.4	0.5	
	Aug	Tree, flooded	0.6 – 0.8	0.25	
	Sep	Tree, flooded	0.7 – 1.05	0.25	
	Oct	Tree, flooded	0.7 – 1.05	0.25	
	Nov	Tree, Grass	0.7 – 0.9	0.25	
	Dec	Tree	0.5 – 0.8	0.32 – 0.37	
ST3	Jan	Grass	0.05 – 0.1	0.13 – 0.39	0.1
	Feb	Dry Grass	0.0 – 0.05	0.04 – 0.13	0.1
	Mar	Dry Grass	0.0 – 0.05	0.0	0.1 – 0.2
	Apr	Grass	0.1 – 0.3	0.0	0.2 – 0.3
	May	Green grass	0.6	0.0	0.2 – 0.3
	June	Green grass	0.65 – 0.85	0.34 – 0.54	0.2 – 0.4
	July	Green grass	0.73 – 1.03	0.16 – 0.24	0.2 – 0.4
	Aug	Green grass	0.83 – 1.03	0.09 – 0.22	0.2 – 0.4
	Sep	Green grass	0.83 – 0.98	0.14 – 0.22	0.2 – 0.4
	Oct	Green grass	0.78 – 0.93	0.19 – 0.22	0.2 – 0.3

Location	Month	Vegetation	Kcb	Ke	Root depth (m)
	Nov	Green grass	0.4 – 0.6	0.51	0.1 – 0.3
	Dec	Grass	0.05 – 0.1	0.4 – 0.67	0.1
WL1	Jan	Bare soil	0.0 – 0.1	0.29 – 0.63	0.0 – 0.2
	Feb	Bare soil	0.0 – 0.1	0.16 – 0.42	0.0 – 0.2
	Mar	Bare soil	0.10	0.07 – 0.25	0.05 – 0.3
	Apr	Grass	0.30 – 0.4	0.03 – 0.1	0.1 – 0.3
	May	Grass	0.40	0.02 – 0.08	0.1 – 0.5
	June	Grass	0.70 – 0.9	0.01 – 0.02	0.1 – 0.5
	July	Grass	0.89 – 1.09	0.13	0.1 – 0.5
	Aug	Flooded	0.1 – 0.2	0.92 - 1.01	0.1 – 0.4
	Sep	Flooded	0.1 – 0.2	0.92 - 1.01	0.0 – 0.1
	Oct	Flooded	0.1 – 0.2	0.92 - 1.01	0.0 – 0.1
	Nov	Grass	0.2 – 0.5	0.58 – 0.62	0.05 – 0.2
	Dec	Grass	0.2 – 0.4	0.37 – 0.57	0.05 – 0.2
WL2	Jan	Bare soil	0.0 – 0.1	0.11 – 0.57	0.0 – 0.1
	Feb	Bare soil	0.0 – 0.1	0.03 – 0.24	0.0 – 0.1
	Mar	Bare soil	0.1 – 0.2	0.0 – 0.07	0.05 – 0.1
	Apr	Grass	0.2 – 0.3	0.0 – 0.02	0.05 – 0.2
	May	Grass	0.4 – 0.4	0.0 – 0.01	0.15 – 0.3
	June	Grass	0.45 – 0.6	0.0	0.15 – 0.3
	July	Grass	0.5 – 0.7	0.55 - 0.75	0.15 – 0.3
	Aug	Grass	0.45 – 1.0	0.12 - 0.22	0.1 – 0.3
	Sep	Flooded	0.3 – 1.0	0.12 - 0.22	0.1 – 0.3
	Oct	Grass	0.2 – 0.7	0.42 - 0.67	0.15 – 0.2
	Nov	Grass	0.1 – 0.2	0.77	0.15 – 0.2
	Dec	Grass	0.0 – 0.1	0.32 – 0.9	0.05 – 0.1
WL3	Jan	Bare soil	0.0 – 0.1	0.28 – 0.6	0.1 – 0.2
	Feb	Bare soil	0.0 – 0.1	0.15 – 0.4	0.1 – 0.2
	Mar	Bare soil	0.1 – 0.1	0.06 – 0.23	0.1 – 0.5
	Apr	Grass	0.2 – 0.4	0.03 – 0.09	0.2 – 0.5
	May	Grass	0.4	0.01 – 0.08	0.2 – 0.6
	June	Grass	0.4 – 0.9	0.01 - 0.01	0.2 – 0.6
	July	Grass	0.79 – 1.09	0.13	0.2 – 0.6
	Aug	Flooded	0.1 – 0.2	0.92 - 1.01	0.2 – 0.6
	Sep	Flooded	0.0 – 0.1	1.01	0.2 – 0.6
	Oct	Flooded	0.0 – 0.1	1.01	0.2 – 0.5
	Nov	Grass	0.2 – 0.5	0.58	0.1 – 0.5
	Dec	Grass	0.1 – 0.4	0.1 - 0.41	0.1 – 0.2

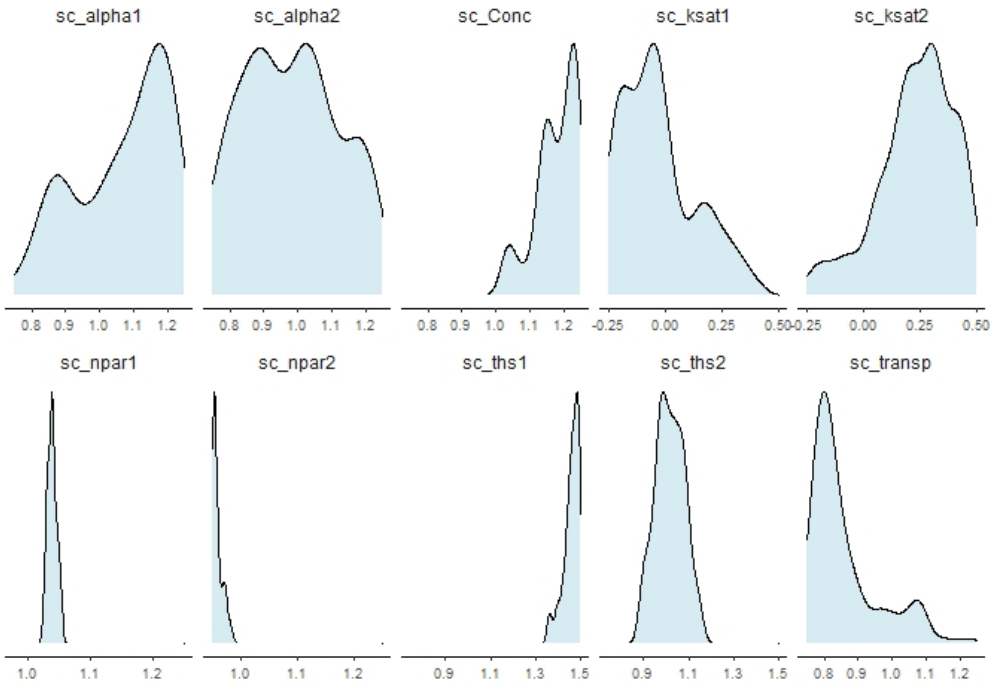


Fig. S1: posterior density distributions of the scaling factors used in the calibration of model ST1. Numbers indicate the individual model layers. Range of x-axes corresponds to prior distribution (parameter alpha of the Mualem-van Genuchten equation: sc_alpha1. sc_alpha2: alpha; sc_Conc: input chloride concentration; sc_ksat1. sc_ksat2: saturated hydraulic conductivity; sc_npar1. sc_npar2: parameter n of the Mualem-van Genuchten equation ; sc_ths1. sc_ths2: saturated water content; sc_transp: transpiration fraction in the evapotranspiration; 1: upper layer; 2: lower layer).

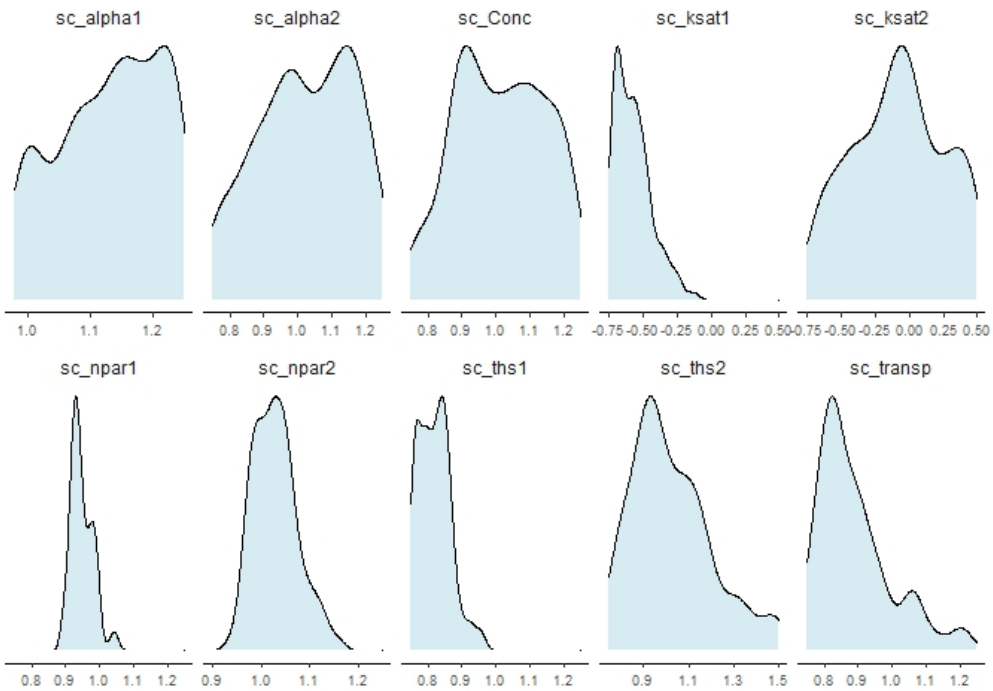


Fig. S2: posterior density distributions of the scaling factors used in the calibration of model ST2. Numbers indicate the individual model layers. Range of x-axes corresponds to prior distribution.

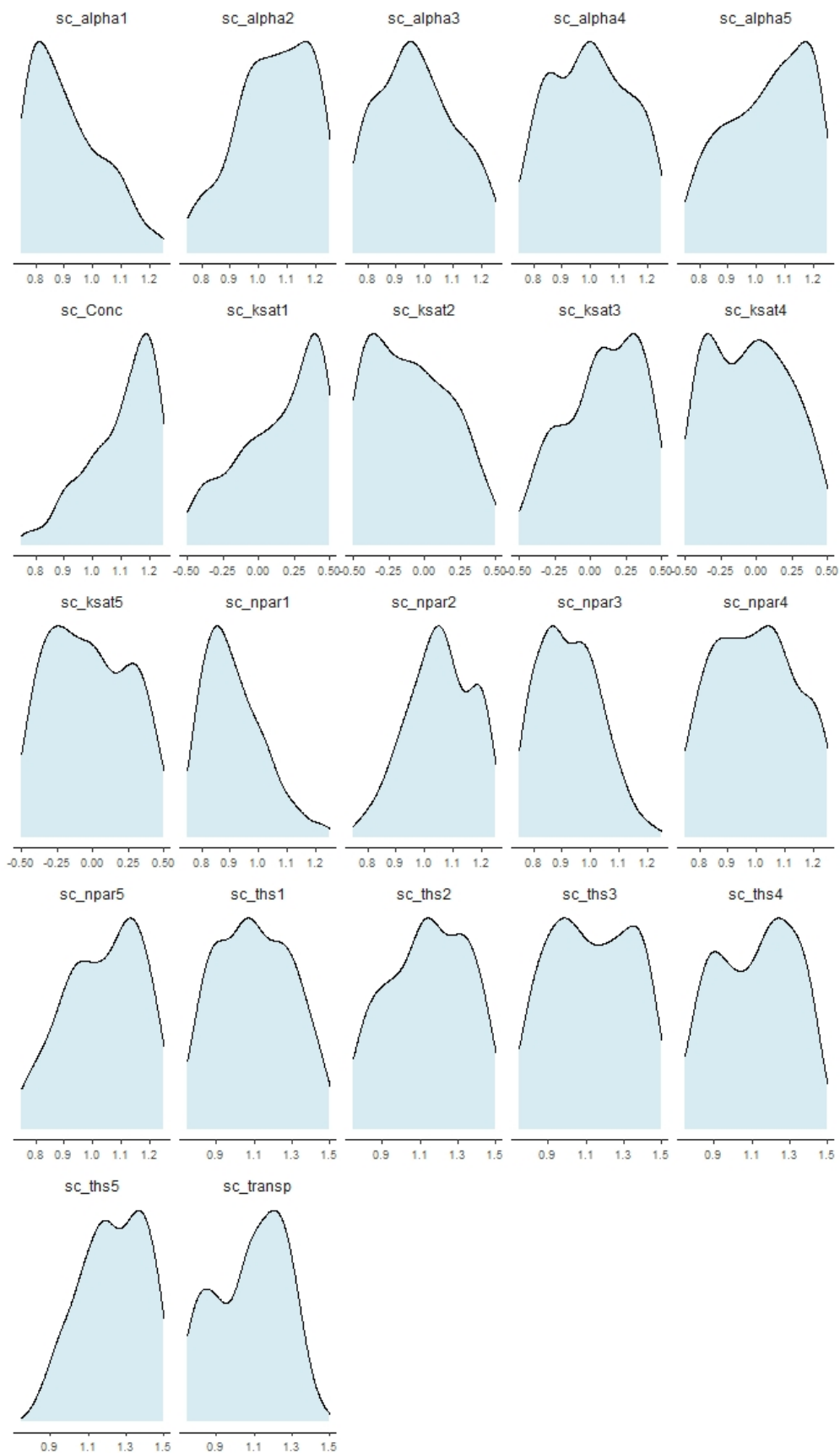


Fig. S3: posterior density distributions of the scaling factors used in the calibration of model ST3. Numbers indicate the individual model layers. Range of x-axes corresponds to prior distribution.

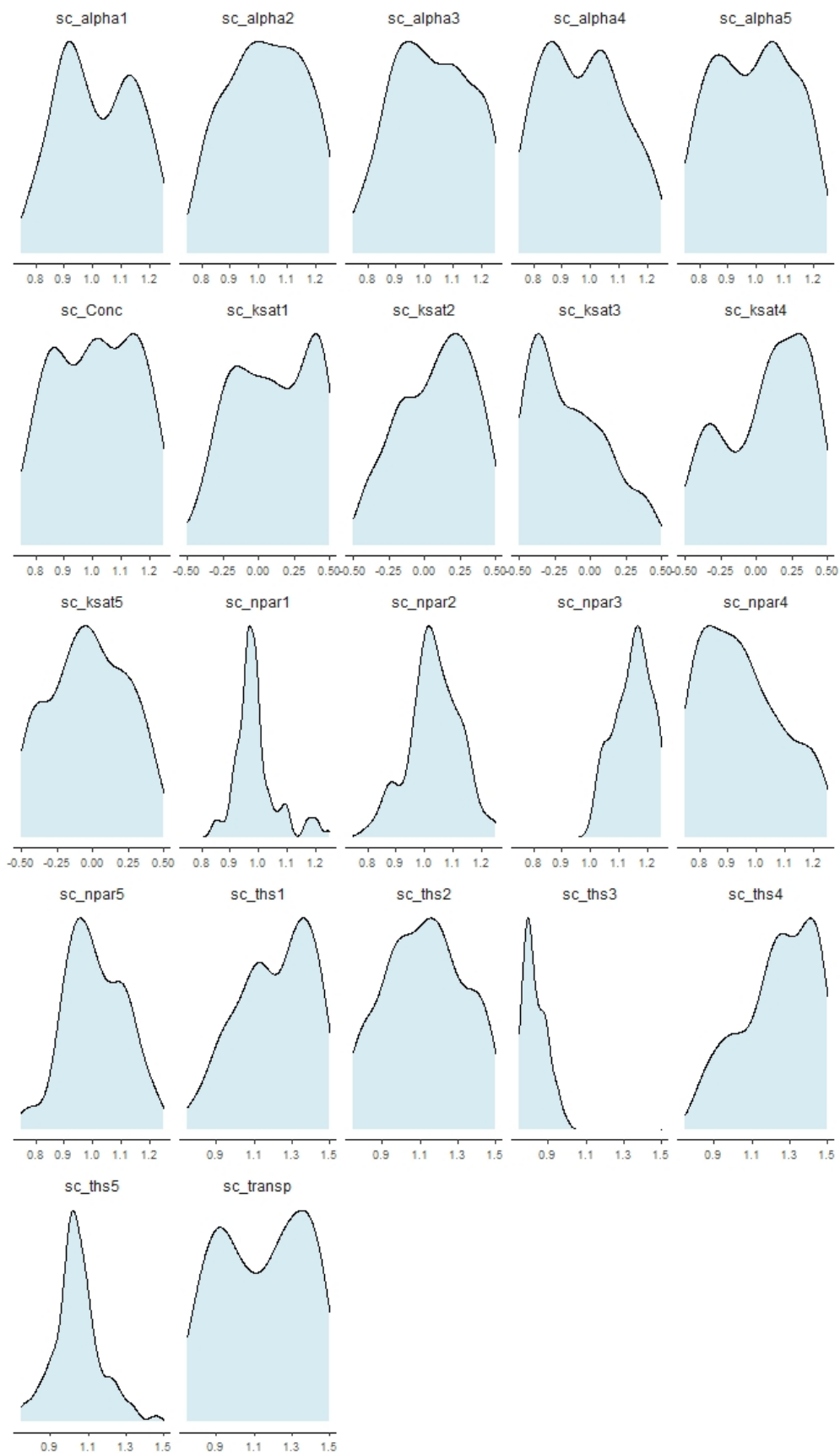


Fig. S4: posterior density distributions of the scaling factors used in the calibration of model WL1. Numbers indicate the individual model layers. Range of x-axes corresponds to prior distribution.

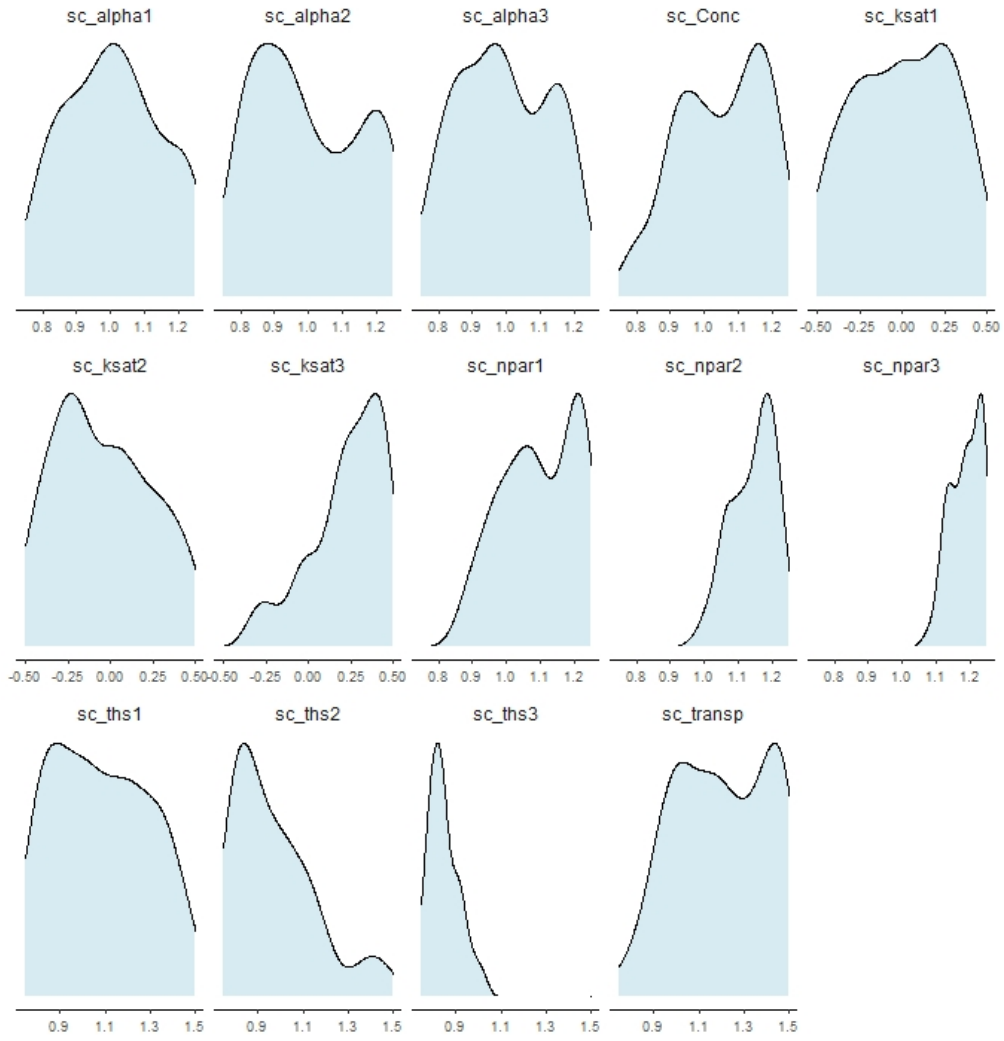


Fig. S5: posterior density distributions of the scaling factors used in the calibration of model WL2. Numbers indicate the individual model layers. Range of x-axes corresponds to prior distribution.

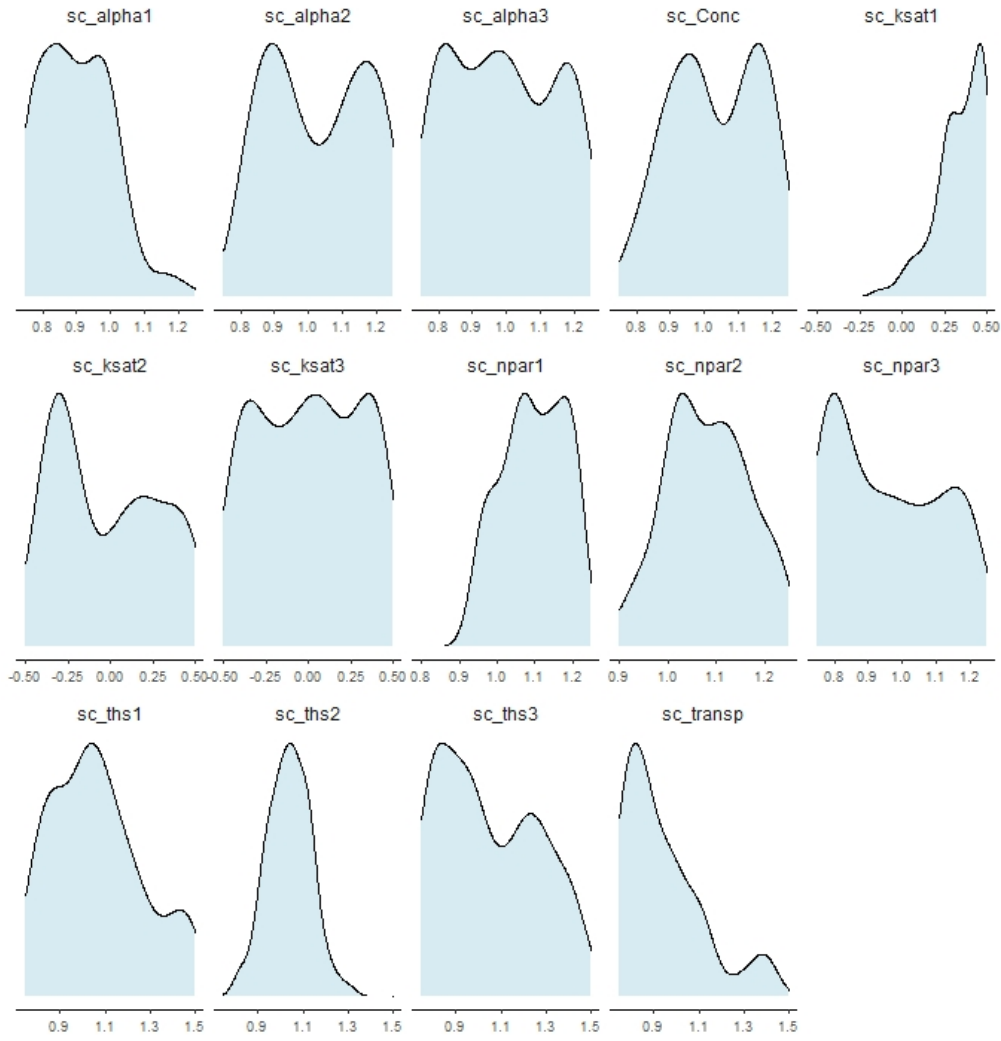


Fig. S6: posterior density distributions of the scaling factors used in the calibration of model WL3. Numbers indicate the individual model layers. Range of x-axes corresponds to prior distribution.