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Response of water use efficiency to summer drought in a boreal Scots pine forest in Finland

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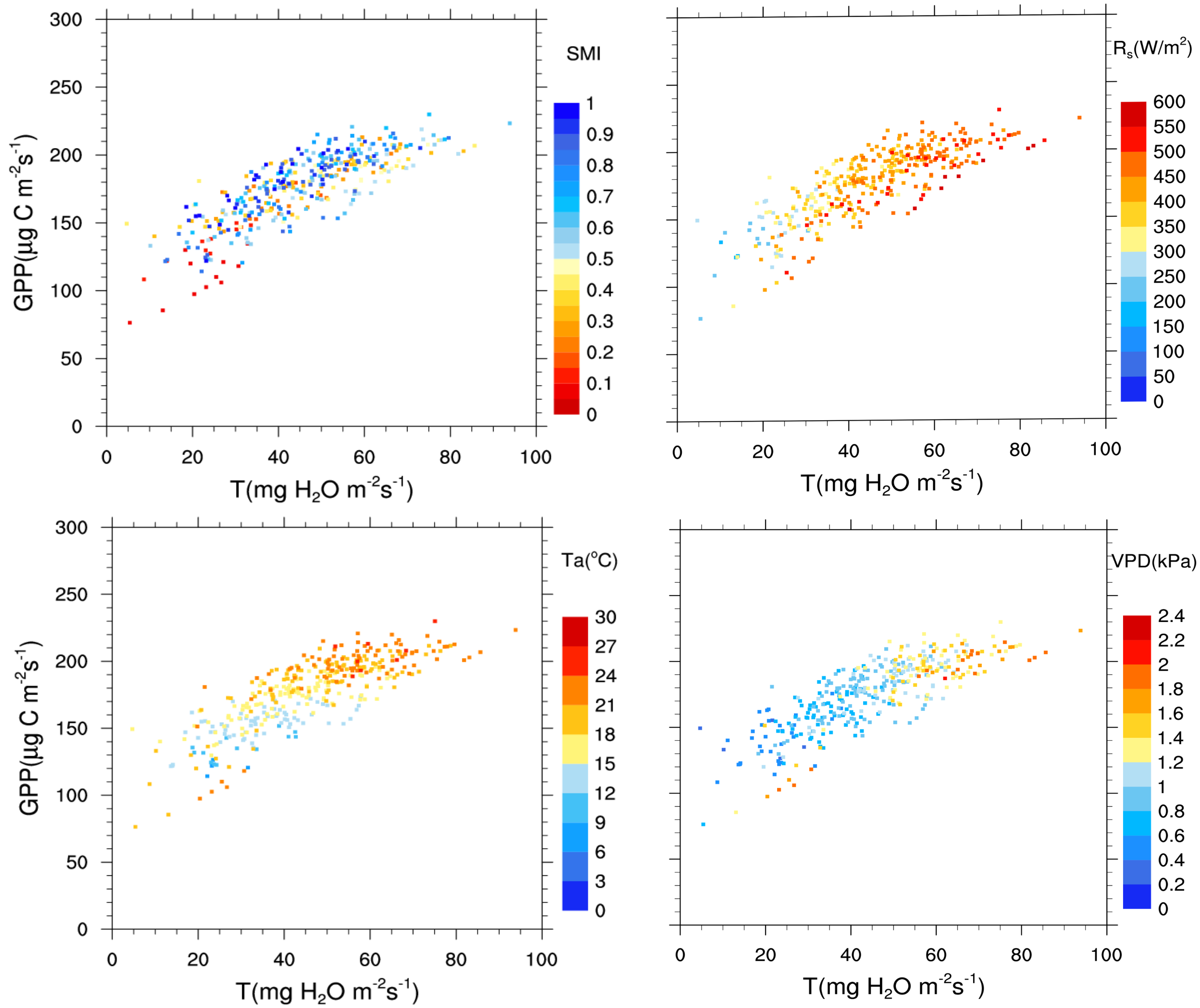

Figure S1: Relationship between the daytime averaged gross primary production (GPP in µg C $m^{-2}s^{-1}$) and transpiration (T in mg H_2O m^{-2} s^{-1}) at Hyytiälä in the summer months (June, July, August) of the 11-year study period (from 1999 to 2009) from the JSBACH simulation. Data are categorized according to daily mean soil moisture index (SMI), daytime mean incoming shortwave radiation (R_s), daytime mean air temperature (T_a) and daytime mean vapour pressure deficit (VPD), respectively.

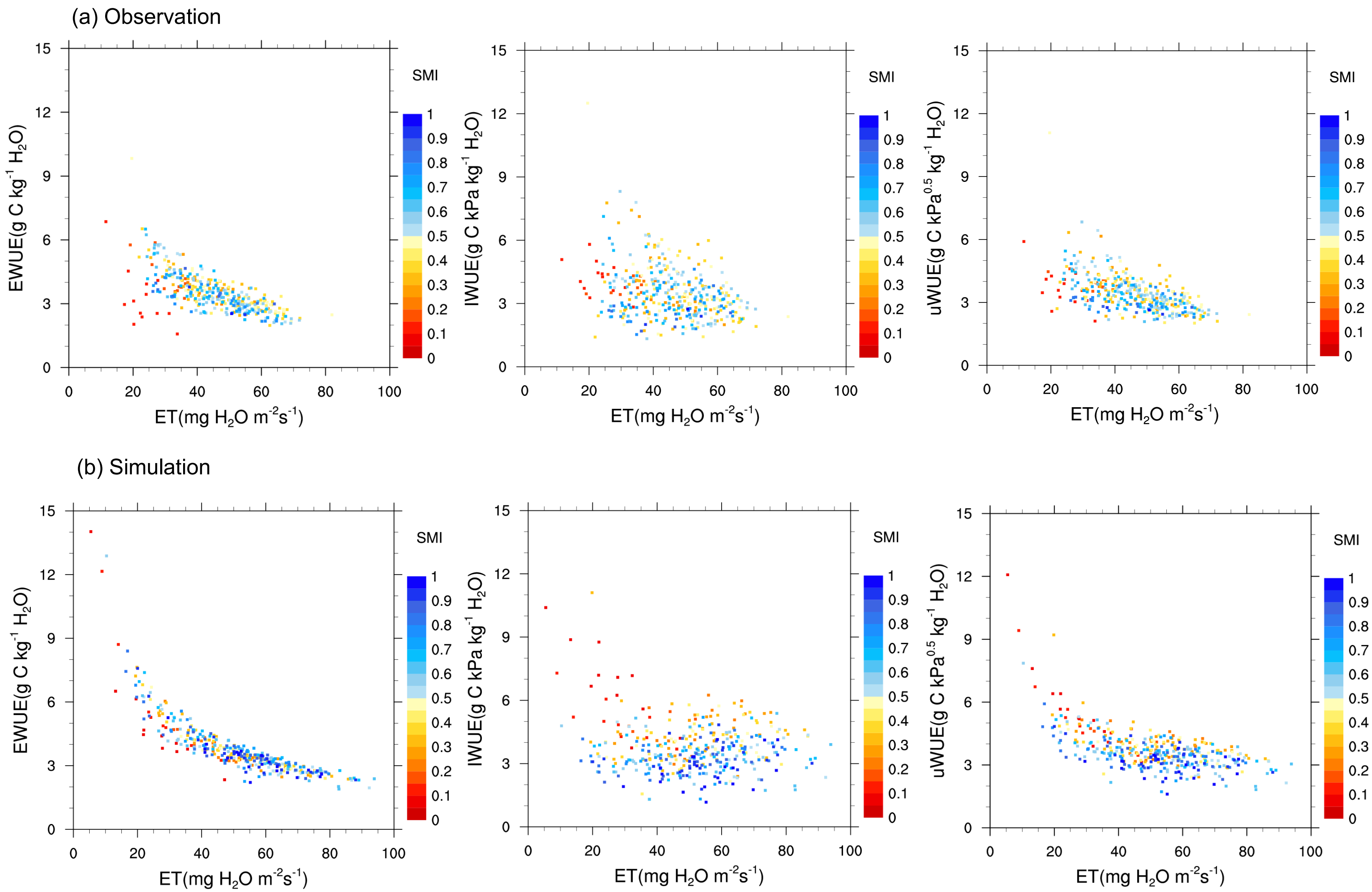

Figure S2: Relationship between the ecosystem level water use efficiency (EWUE) and evapotranspiration (ET), relationship between the inherent water use efficiency (IWUE) and ET, and relationship between the underlying water use efficiency (uWUE) and ET at Hyytiälä in the summer months (June, July, August) of the 11-year study period (from 1999 to 2009) from (a) observation and (b) the JSBACH simulation.

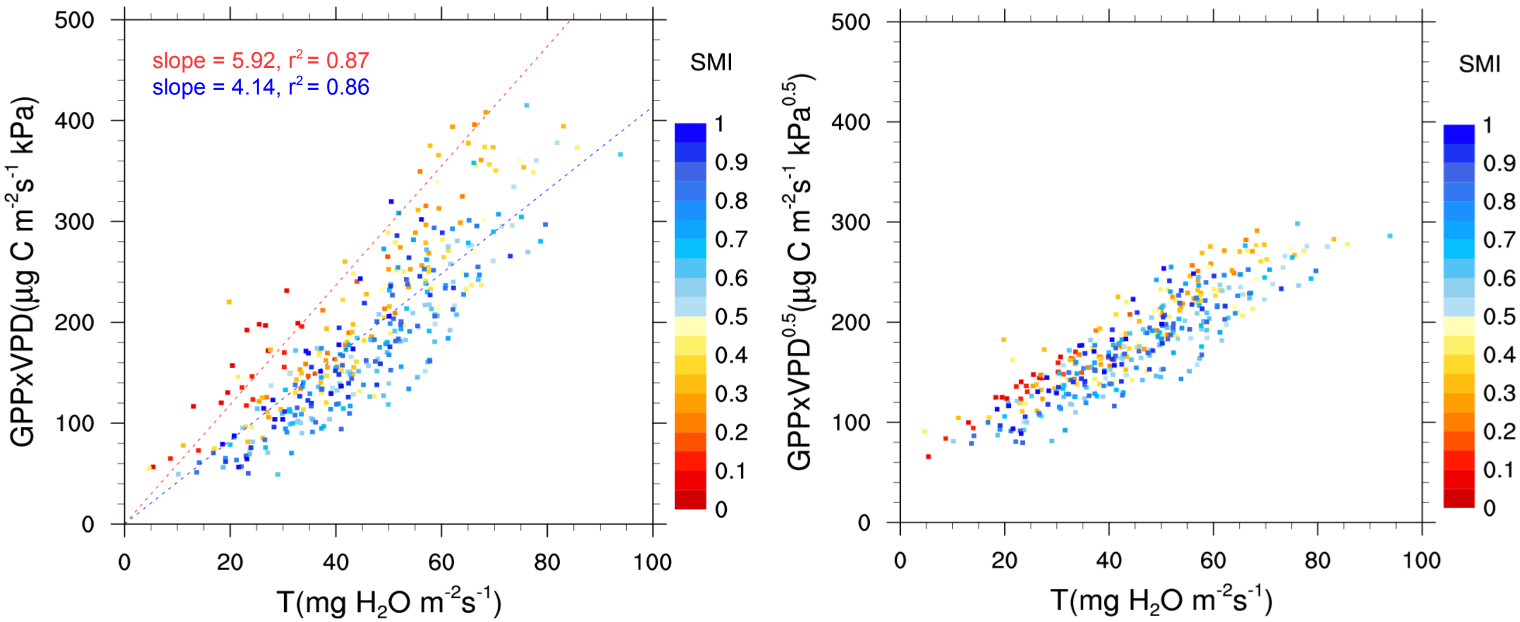

Figure S3: The dependence of the product of daytime mean gross primary production (GPP in μg C $m^{-2}s^{-1}$) and daytime mean vapour pressure deficit (VPD) on transpiration (T in mg H_2O m^{-2} s^{-1}) (i.e., GPP×VPD/T, which represents the transpiration-based inherent water use efficiency), and the dependence of the production of GPP and the square root of VPD on T (i.e., GPP×$VPD^{0.5}$/ET, which represents the transpiration-based underlying water use efficiency) in the summer months (June, July, August) of the 11-year study period (from 1999 to 2009) from the JSBACH simulation. Data are categorized according to daily mean soil moisture index (SMI). The fitted lines for the dependence of the product of GPP and VPD on T are for the data under SMI < 0.2 (red line) and data under 0.2 ≤ SMI <1 (blue line); the fittings are statistically significant (p-value < 0.01). No lines were fitted for the dependence of the production of GPP and the square root of VPD on ET, as the data under SMI < 0.2 and data under 0.2 ≤ SMI <1 are more converged in a line in comparison to the dependence of the product of GPP and VPD on T.

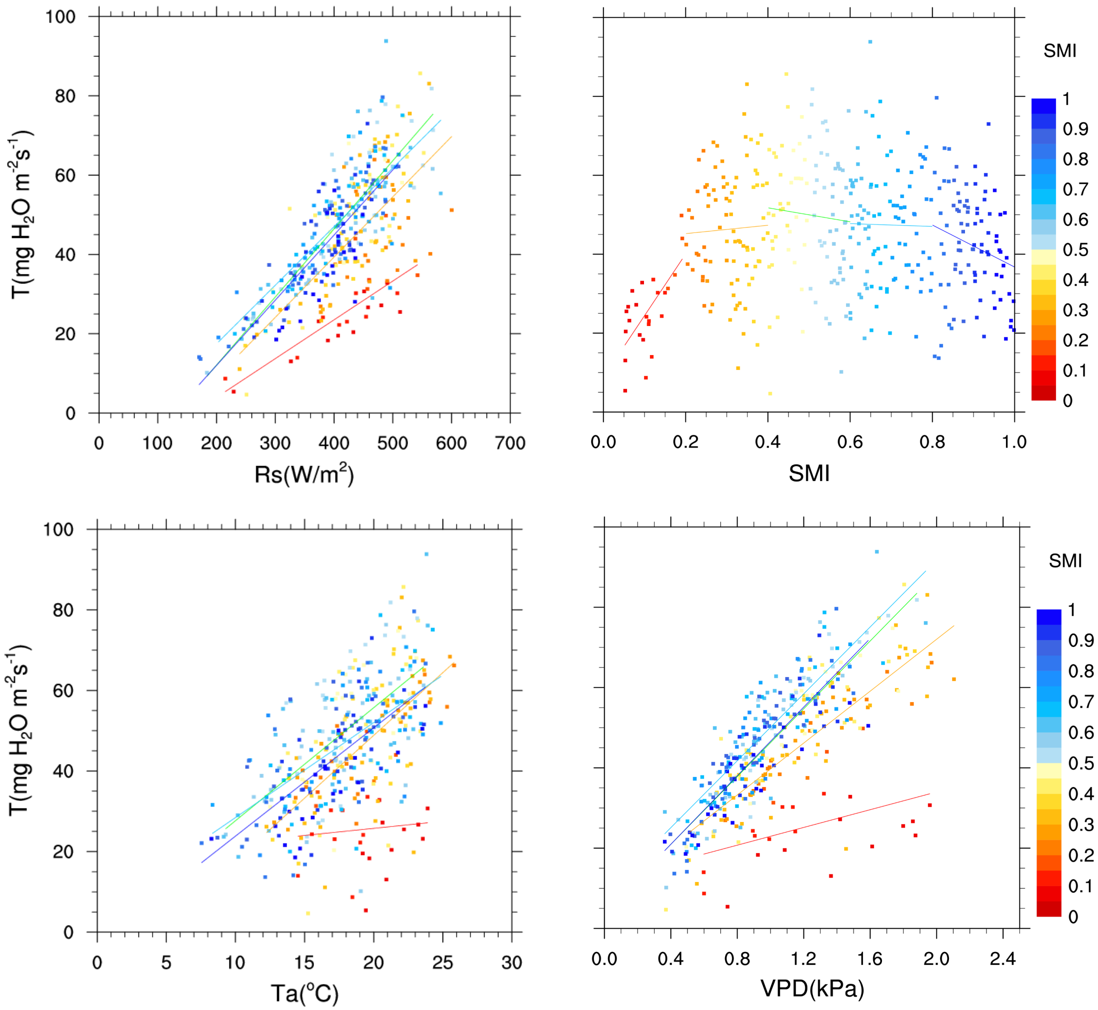

Figure S4: Response of daytime mean transpiration (T in mg H_2O m^{-2} s^{-1}) to daytime mean incoming shortwave radiation (R_s), daytime mean air temperature (T_a), daytime mean vapour pressure deficit (VPD), and daily mean soil moisture index (SMI) at Hyytiälä, categorized by daily mean soil moisture index (SMI) in the summer months (June, July, August) of the 11-year study period (from 1999 to 2009) from the JSBACH simulation. The regression lines are fitted for the five SMI groups (very dry: $0 \le SMI < 0.2$, moderate dry: $0.2 \le SMI < 0.4$, mid-range: $0.4 \le SMI < 0.6$, moderate wet: $0.6 \le SMI < 0.8$, very wet: $0.8 \le SMI < 1$).

Table S1: Regression parameters, correlation coefficient and statistical significance (p-value) of the dependences of the daytime averaged gross primary production (GPP in µg C $m^{-2}s^{-1}$), evapotranspiration (ET in mg H_2O m^{-2} s^{-1}), transpiration (T in mg H_2O m^{-2} s^{-1}) on the environmental variables (daytime mean incoming shortwave radiation (R_s), daytime mean air temperature (T_a), daytime mean vapour pressure deficit (VPD) and daily mean soil moisture index (SMI)) for the five SMI groups (N1: very dry (0 ≤ SMI < 0.2), N2: moderate dry (0.2 ≤ SMI < 0.4), N3: mid-range (0.4 ≤ SMI < 0.6), N4: moderate wet (0.6 ≤ SMI < 0.8), N5: very wet (0.8 ≤ SMI < 1)). The regressions with p-values smaller than 0.05 are considered to be statistically significant.

Environmental variable			R_s				T_a				SMI				VPD			
Fitting function			Linear function				Linear function				Linear function				Linear function			
Parameter			slope	interception	r	p-value	slope	interception	r	p-value	slope	interception	r	p-value	slope	interception	r	p-value
GPP	observation	N1	-0.01	102.90	0.03	0.87	-12.01	366.27	0.80	0.00	1460.45	-124.09	0.79	0.00	-64.20	174.77	0.74	0.00
		N2	0.06	133.75	0.18	0.08	-0.88	174.34	0.14	0.21	-42.30	172.26	0.08	0.44	-12.19	170.66	0.20	0.04
		N3	-0.02	164.47	0.05	0.48	-0.54	168.45	0.08	0.35	-78.55	197.20	0.21	0.01	-22.38	182.51	0.39	0.00
		N4	-0.05	168.20	0.19	0.05	0.63	135.69	0.11	0.23	-69.42	194.10	0.17	0.07	-17.90	163.61	0.24	0.01
		N5	-0.32	265.49	0.62	0.02	3.51	88.58	0.39	0.18	20.96	123.46	0.03	0.91	-0.635	142.06	0.00	0.99
	simulation	N1	0.18	52.37	0.57	0.00	-3.40	193.31	0.35	0.09	530.44	70.53	0.92	0.00	-6.21	135.05	0.10	0.64
		N2	0.14	118.37	0.48	0.00	4.67	89.85	0.85	0.00	38.86	167.46	0.11	0.31	34.72	137.58	0.74	0.00
		N3	0.17	107.09	0.65	0.00	5.49	79.98	0.85	0.00	-50.86	204.00	0.15	0.17	47.16	127.10	0.77	0.00
		N4	0.18	109.55	0.56	0.00	5.90	76.51	0.91	0.00	-5.48	186.77	0.00	0.90	67.48	119.83	0.79	0.00
		N5	0.25	79.70	0.72	0.00	6.06	73.98	0.91	0.00	41.25	139.15	0.09	0.40	70.47	112.84	0.84	0.00
ET	observation	N1	0.05	8.71	0.59	0.00	-0.96	46.15	0.31	0.13	266.19	-13.41	0.71	0.00	-0.93	28.12	0.00	0.81
		N2	0.05	27.58	0.29	0.00	0.69	34.18	0.20	0.05	44.63	31.87	0.17	0.10	3.05	43.68	0.01	0.31
		N3	0.03	35.14	0.24	0.00	0.87	32.94	0.22	0.01	-18.35	58.58	0.09	0.27	3.42	45.73	0.01	0.19
		N4	0.05	22.96	0.36	0.00	1.35	21.74	0.48	0.00	32.45	21.96	0.16	0.09	12.98	31.72	0.36	0.00
		N5	-0.06	66.55	0.30	0.31	2.33	7.57	0.66	0.01	71.61	-19.03	0.30	0.31	25.31	23.20	0.49	0.09
	simulation	N1	0.12	-20.16	0.79	0.00	0.50	19.13	0.11	0.61	148.14	12.95	0.55	0.01	12.69	13.15	0.42	0.04
		N2	0.17	-22.60	0.73	0.00	2.63	1.03	0.60	0.00	9.30	48.59	0.03	0.76	29.51	15.87	0.79	0.00
		N3	0.18	-23.07	0.88	0.00	2.41	11.19	0.47	0.00	-22.97	66.03	0.08	0.44	38.30	12.85	0.79	0.00
		N4	0.19	-22.89	0.86	0.00	2.10	15.07	0.48	0.00	-24.13	69.57	0.08	0.41	45.11	10.77	0.78	0.00
		N5	0.19	-18.58	0.84	0.00	2.52	10.04	0.59	0.00	60.27	-1.50	0.20	0.05	43.32	13.64	0.81	0.00
T	simulation	N1	0.10	-15.60	0.78	0.00	0.35	18.73	0.09	0.68	156.34	8.79	0.67	0.00	11.04	11.90	0.44	0.03
		N2	0.15	-21.42	0.68	0.00	3.11	-13.46	0.72	0.00	10.59	43.10	0.03	0.73	32.32	7.39	0.88	0.00
		N3	0.17	-22.26	0.84	0.00	2.81	-0.41	0.56	0.00	-17.76	58.86	0.06	0.54	42.22	4.06	0.89	0.00
		N4	0.15	-12.08	0.79	0.00	2.36	4.86	0.63	0.00	-3.58	49.90	0.01	0.88	41.66	8.44	0.84	0.00
		N5	0.16	-20.81	0.82	0.00	2.69	-3.05	0.70	0.00	-53.28	90.02	0.20	0.06	42.72	3.87	0.88	0.00