



Supplement of

Response of water fluxes and biomass production to climate change in permanent grassland soil ecosystems

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Table S 1: Site-specific cutting dates during 1st January 2015 until 31th December 2018.

Year	Cutting regimes	Gumpenstein	Rollesbroich	Selhausen
2015	1 st	05-27	05-26	05-26
	2 nd	07-28	06-29	06-30
	3 rd	10-13	08-21	08-21
	4 th	-	10-14	10-13
2016	1 st	05-31	06-07	06-07
	2 nd	07-26	07-12	07-12
	3 rd	10-04	08-30	08-30
	4 th	-	10-18	10-18
2017	1 st	05-30	05-15	05-16
	2 nd	07-25	06-21	06-21
	3 rd	10-03	08-29	08-29
2018	1 st	05-29	05-07	05-08
	2 nd	07-24	06-26	06-26
	3 rd	10-02	09-11	09-11

Table S 2: Start of the growing and non-growing season as well as the duration of the growing season during 1 January 2015 until 31 December 2018 at the corresponding site Gumpenstein (GS), Rollesbroich (RO), and Selhausen (SE).

Year	Start growing season			Start non-growing season			Duration growing season (days)		
	GS	RO	SE	GS	RO	SE	GS	RO	SE
2015	04-14	04-12	03-13	10-23	11-09	11-18	192	211	250
2016	04-02	04-05	03-05	10-15	10-23	11-02	196	201	242
2017	03-29	03-20	03-08	10-14	10-23	11-05	199	217	242
2018	04-11	04-07	03-14	10-27	10-25	11-08	199	201	239

Table S 3: Average amounts of precipitation during growing and non-growing seasons from 1 January 2015 until 31 December 2018. The values were averaged across replicated lysimeter measurements at each test sites Gumpenstein (GS) four treatments C2T0 (CO₂: +300 ppm, two lysimeter), C0T2 (temperature: +3°C, two lysimeter), C0T0 (ambient, one lysimeter), C2T2 (CO₂: +300 ppm, and temperature: +3°C, one lysimeter), Rollesbroich (RO) with C0CL0 (original, six lysimeter) and Selhausen (SE) with C0CL2 (translocated, three lysimeter).

Year	Season	Precipitation						10
		Gumpenstein				Rollesbroich	Selhausen	
		C2T0	C0T2	C0T0	C2T2	C0CL0	C0CL2	
		mm						
2015	non-growing	331.0	310.6	308.3	305.4	580.9	225.3	
	growing	700.3	670.4	711.0	648.8	510.9	475.1	
	annual	1031.3	981.1	1019.3	954.2	1091.8	700.4	
2016	non-growing	431.4	406.2	413.7	387.7	492.2	224.1	
	growing	776.0	724.2	747.0	726.9	546.7	445.3	
	annual	1207.3	1130.4	1160.7	1114.5	1038.9	669.4	
2017	non-growing	458.0	459.2	463.9	464.6	506.9	199.6	
	growing	844.5	829.7	842.2	826.9	569.4	402.5	
	annual	1302.5	1288.8	1306.1	1291.4	1076.4	602.2	
2018	non-growing	410.0	427.2	437.2	427.1	484.0	201.5	
	growing	573.9	556.8	575.4	563.1	388.3	283.8	
	annual	983.9	984.1	1012.6	990.3	872.3	485.3	
Average	non-growing	407.6	400.8	405.8	396.2	516.0	212.6	
	growing	723.7	695.3	718.9	691.4	503.8	401.7	
	annual	1131.3	1096.1	1124.7	1087.6	1019.8	614.3	

Table S 4: Average amounts of non-rainfall water during growing and non-growing seasons from 1 January 2015 until 31 December 2018. The values were averaged across replicated lysimeter measurements at each test sites Gumpenstein (GS) four treatments C2T0 (CO₂: +300 ppm, two lysimeter), C0T2 (temperature: +3°C, two lysimeter), C0T0 (ambient, one lysimeter), C2T2 (CO₂: +300ppm, and temperature: +3°C, one lysimeter), Rollesbroich (RO) with C0CL0 (original, six lysimeter) and Selhausen (SE) with C0CL2 (translocated, three lysimeter).

Year	Season	Non-rainfall water					
		Gumpenstein				Rollesbroich	Selhausen
		C2T0	C0T2	C0T0	C2T2	C0CL0	C0CL2
mm							
2015	non-growing	50.8	30.8	30.4	27.7	30.1	18.3
	growing	25.5	18.3	20.9	17.4	26.8	30.4
	annual	76.3	49.1	51.3	45.1	56.9	48.7
2016	non-growing	56.8	32.8	44.0	26.0	36.9	21.5
	growing	36.0	23.9	30.3	22.8	27.0	22.8
	annual	92.8	56.6	74.3	48.8	63.8	44.2
2017	non-growing	45.5	42.4	43.9	40.6	30.5	25.3
	growing	32.3	22.5	29.2	21.4	26.2	21.4
	annual	77.8	65.0	73.1	62.0	56.7	46.7
2018	non-growing	39.1	40.7	41.4	39.6	26.2	21.5
	growing	19.0	13.2	18.5	13.7	19.1	16.6
	annual	58.1	53.9	59.9	53.3	45.4	38.1
Average	non-growing	48.1	36.7	39.9	33.5	30.9	21.6
	growing	28.2	19.5	24.7	18.8	24.8	22.8
	annual	76.3	56.1	64.6	52.3	55.7	44.4

Table S 5: Non-rainfall water as percentage of precipitation amounts during growing and non-growing seasons from 1 January 2015 until 31 December 2018. The values were averaged across replicated lysimeter measurements at each test sites Gumpenstein (GS) four treatments C2T0 (CO₂: +300 ppm, two lysimeter), C0T2 (temperature: +3°C, two lysimeter), C0T0 (ambient, one lysimeter), C2T2 (CO₂: +300ppm, and temperature: +3°C, one lysimeter), Rollesbroich (RO) with C0CL0 (original, six lysimeter) and Selhausen (SE) with C0CL2 (translocated, three lysimeter).

Year	Season	Non-rainfall water % of precipitation					
		Gumpenstein				Rollesbroich	Selhausen
		C2T0	C0T2	C0T0	C2T2	C0CL0	C0CL2
% of P							
2015	non-growing	15.3	9.9	9.9	9.1	5.2	8.1
	growing	3.6	2.7	2.9	2.7	5.2	6.4
	annual	7.4	5.0	5.0	4.7	5.2	6.9 40
2016	non-growing	13.2	8.1	10.6	6.7	7.5	9.6
	growing	4.6	3.3	4.1	3.1	4.9	5.1
	annual	7.7	5.0	6.4	4.4	6.1	6.6
2017	non-growing	9.9	9.2	9.5	8.7	6.0	12.7
	growing	3.8	2.7	3.5	2.6	4.6	5.3
	annual	6.0	5.0	5.6	4.8	5.3	7.8
2018	non-growing	9.5	9.5	9.5	9.3	5.4	10.7 45
	growing	3.3	2.4	3.2	2.4	4.9	5.8
	annual	5.9	5.5	5.9	5.4	5.2	7.9
Average	non-growing	11.8	9.2	9.8	8.5	6.0	10.2
	growing	3.9	2.8	3.4	2.7	4.9	5.7
	annual	6.7	5.1	5.7	4.8	5.5	7.2

50 **Table S 6:** Average amounts of evapotranspiration during growing and non-growing seasons from 1 January 2015 until 31 December 2018. The values were averaged across replicated lysimeter measurements at each test sites Gumpenstein (GS) four treatments C2T0 (CO₂: +300 ppm, two lysimeter), C0T2 (temperature: +3°C, two lysimeter), C0T0 (ambient, one lysimeter), C2T2 (CO₂: +300ppm, and temperature: +3°C, one lysimeter), Rollesbroich (RO) with C0CL0 (original, six lysimeter) and Selhausen (SE) with C0CL2 (translocated, three lysimeter).

Year	Season	Evapotranspiration						55
		Gumpenstein				Rollesbroich	Selhausen	
		C2T0	C0T2	C0T0	C2T2	C0CL0	C0CL2	
mm								
2015	non-growing	128.9	125.3	108.4	114.0	108.5	115.4	
	growing	488.3	684.4	620.4	649.0	550.5	690.6	
	annual	617.2	809.7	728.8	763.0	659.0	806.0	
2016	non-growing	128.0	155.6	114.6	143.3	79.0	80.8	60
	growing	510.2	699.6	568.3	656.4	531.5	582.6	
	annual	638.2	855.2	682.9	799.7	610.6	663.4	
2017	non-growing	106.5	129.7	111.5	117.2	66.3	71.7	
	growing	594.9	741.3	673.2	689.9	577.1	610.8	
	annual	701.4	871.1	784.7	807.0	643.4	682.5	
2018	non-growing	96.2	124.3	103.9	125.4	95.3	86.9	
	growing	573.2	662.0	619.0	584.9	548.8	500.1	65
	annual	669.4	786.3	722.9	710.3	644.1	587.0	
Average	non-growing	114.9	133.7	109.6	125.0	87.3	88.7	
	growing	541.6	696.8	620.2	645.0	552.0	596.1	
	annual	656.5	830.5	729.8	770.0	639.3	684.7	

70 **Table S 7:** Average amounts of water flux across the lysimeter bottom (NetQ) during the growing and non-growing seasons from 1 January 2015 until 31 December 2018. The values were averaged across replicated lysimeter measurements at each test sites Gumpenstein (GS) four treatments C2T0 (CO₂: +300 ppm, two lysimeter), C0T2 (temperature: +3°C, two lysimeter), C0T0 (ambient, one lysimeter), C2T2 (CO₂: +300ppm, and temperature: +3°C, one lysimeter), Rollesbroich (RO) with C0CL0 (original, six lysimeter) and Selhausen (SE) with C0CL2 (translocated, three lysimeter). Positive NetQ values are denoted as seepage and negative NetQ values as upward directed water from deeper soil layers or groundwater table.

Year	Season	NetQ					
		Gumpenstein				Rollesbroich	Selhausen
		C2T0	C0T2	C0T0	C2T2	C0CL0	C0CL2
		mm					
2015	non-growing	294.7	220.3	259.2	201.2	526.5	16.2
	growing	237.9	11.1	98.0	12.9	-5.6	-45.1
	annual	532.6	231.4	357.2	214.0	521.0	-29.0
2016	non-growing	312.8	198.9	285.6	208.7	382.5	32.8
	growing	287.2	65.9	194.6	93.3	106.3	-21.4
	annual	600.0	264.9	480.2	302.0	488.7	11.4
2017	non-growing	422.4	355.7	381.1	378.2	455.0	25.1
	growing	274.6	137.6	190.1	139.6	40.2	-100.3
	annual	697.0	493.3	571.1	517.9	495.2	-75.2
2018	non-growing	375.9	314.2	378.0	353.2	353.7	45.9
	growing	5.9	3.6	5.6	1.8	-27.7	-66.0
	annual	381.8	317.8	383.6	355.0	325.9	-20.1
Average	non-growing	351.5	272.3	326.0	285.3	429.4	30.00
	growing	201.4	54.5	122.1	61.9	28.3	-58.22
	annual	552.9	326.8	448.0	347.2	457.7	-28.2

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Table S 8: Average changes of the soil water storage (ΔS) during the growing and non-growing seasons from 1 January 2015 until 31 December 2018. The values were averaged across replicated lysimeter measurements at each test sites Gumpenstein (GS) four treatments C2T0 (CO₂: +300 ppm, two lysimeter), C0T2 (temperature: +3°C, two lysimeter), C0T0 (ambient, one lysimeter), C2T2 (CO₂: +300ppm, and temperature: +3°C, one lysimeter), Rollesbroich (RO) with C0CL0 (original, six lysimeter) and Selhausen (SE) with C0CL2 (translocated, three lysimeter). Positive values are denoted as a decreasing and positive as an increasing ΔS .

Year	Season	ΔS					
		Gumpenstein				Rollesbroich	Selhausen
		C2T0	C0T2	C0T0	C2T2	C0CL0	C0CL2
		mm					
2015	non-growing	-41.8	-4.2	-28.9	17.9	-24	112
	growing	-0.4	-6.8	13.5	4.3	-7.2	-140
	annual	-42.2	-10.9	-15.4	22.3	-31.3	-27.9
2016	non-growing	47.4	84.5	57.5	61.7	67.6	132
	growing	14.6	-17.4	14.4	0.0	-64.1	-93.1
	annual	61.9	66.9	71.9	61.6	3.4	38.8
2017	non-growing	-25.4	16.2	15.2	9.8	16.1	128.1
	growing	7.3	-26.7	8.1	18.8	-21.7	-86.6
	annual	-18.1	-10.6	23.4	28.5	-5.5	41.6
2018	non-growing	-23	29.4	-3.3	-11.9	61.2	90.2
	growing	13.8	-95.6	-30.7	-9.9	-113.7	-133.7
	annual	-9.2	-66.1	-34	-21.7	-52.3	-43.5
Average	non-growing	-10.7	31.5	10.1	19.4	30.2	115.5
	growing	8.9	-36.5	1.3	3.3	-51.7	-113.38
	annual	-1.8	-5.1	11.5	22.7	-21.5	2.2

110 **Table S 9:** Information on the average dry aboveground biomass (g m^{-2}) from 1 January 2015 until 31 December 2018. The values were averaged across replicated lysimeter measurements at each test sites Gumpenstein (GS) four treatments C2T0 (CO_2 : +300 ppm, two lysimeter), C0T2 (temperature: +3°C, two lysimeter), C0T0 (ambient, one lysimeter), C2T2 (CO_2 : +300ppm, and temperature: +3°C, one lysimeter), Rollesbroich (RO) with C0CL0 (original, six lysimeter) and Selhausen (SE) with C0CL2 (translocated, three lysimeter).

Year	Cutting regimes	Gumpenstein				Rollesbroich	Selhausen
		C2T0	C0T2	C0T0	C2T2	C0CL0	C0CL2
		g m^{-2}					
2015	1 st	287.9	345.7	406.5	299.2	316.3	555.7
	2 nd	183.7	197.5	356.7	183.6	121.0	112.0
	3 rd	115.8	123.1	188.3	150.9	260.0	111.7
	4 th	-	-	-	-	195.2	249.0
2016	1 st	284.1	385.2	369.2	224.3	503.5	528.7
	2 nd	240.5	255.5	359.3	316.1	226.8	214.3
	3 rd	164.2	219.2	415.5	147.6	193.0	69.7
	4 th	-	-	-	-	65.3	21.0
2017	1 st	351.3	364.4	385.7	280.1	56.5	225.7
	2 nd	212.1	234.3	386.5	180.8	424.5	158.3
	3 rd	201.1	167.4	346.4	174.5	222.5	217.0
2018	1 st	404.7	310.1	655.2	232.0	190.7	240.0
	2 nd	204.3	227.9	290.1	186.0	288.2	156.7
	3 rd	152.1	142.9	210.4	165.2	113.8	24.0