1   *Supplement of*

3   Determination of respiration and photosynthesis fractionation

4   coefficients for atmospheric dioxygen inferred from a vegetation-soil-

5   atmosphere analog of the terrestrial biosphere in closed chambers

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Table S1. Summary of empty chamber test (starting 21 October 2020): evolution of isotopic and elementary composition of O$_2$.

Date	$\delta^{18}O$ of O_2 (‰)	$\Delta O_2/N_2$ (‰)
21 October 2020	-0.055	-3.075
29 October 2020	-0.046	-3.628
06 November 2020	-0.051	-6.218
17 November 2020	-0.064	-8.8

Table S2. Complete data set of the different fractionation coefficients ($^{18}\alpha_{soil\_respi}$) and ($^{17}\alpha_{soil\_respi}$) and isotopic discriminations ($^{18}\varepsilon_{soil\_respi}$ and $^{17}\varepsilon_{soil\_respi}$) of dioxygen and respiratory fluxes during soil respiration experiment. μ is the average over all lines above of the different quantities and σ the associated standard deviation.

Sequence	$^{18}\alpha_{soil\_respi}$	$^{18}\varepsilon_{soil\_respi}$ (‰)	$^{17}\alpha_{soil\_respi}$	$^{17}\varepsilon_{soil\_respi}$ (‰)	γ_{soil_respi}	O_2 consumed (mmolO$_2$/day)
1	0.9883	-11.7	0.9940	-6.0	0.5170	2.81
2	0.9861	-13.9	0.9928	-7.2	0.5157	11.78
3	0.9898	-10.2	0.9947	-5.3	0.5163	8.92
4	0.9866	-13.4	0.9930	-6.9	0.5165	6.59
μ	0.9877	-12.3	0.9936	-6.4	0.5164	7.52
σ	0.0017	1.7	0.0009	0.9	0.0005	3.79

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Table S3. Complete data set of the different fractionation coefficients ($^{18}\alpha_{dark\_respi}$) and ($^{17}\alpha_{dark\_respi}$) of dioxygen during dark periods of the photosynthesis and respiration experiment. μ is the average over all lines above of the different quantities and σ the associated standard deviation. The missing data are due to a problem during measurements.

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Sequence	Period	$^{18}\alpha_{dark\_respi}$	$^{17}\alpha_{dark\_respi}$	γ_{dark_respi}	O_2 consumed (mmolO_2/day)
1	1	0.9846	0.9921	0.5105	21.77
	2	0.9844	0.9921	0.5045	21.46
	3	0.9848	0.9922	0.5084	18.57
	4	0.9841	0.9917	0.5224	14.98
2	1	0.9822	0.9909	0.5077	36.61
	2	0.9794			25.93
	3	0.9825	0.9909	0.5183	31.03
3	1	0.9821	0.9911	0.4977	26.17
	2	0.9803	0.9897	0.5238	26.15
	3	0.9853	0.9924	0.5141	31.65
μ		0.9830	0.9914	0.5124	25.43
σ		0.0020	0.0008	0.0084	6.51

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Sensibility tests

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We quantify how much the uncertainties in the fractions of the biological process (dark respiration, photorespiration and the Mehler reaction) could affect the values of dark respiratory and photosynthetic fractionation coefficients determined in our study (Tables S5, S6 and S7). For this, we start from the values given by Landais et al. (2007): f_{dark_respi} (0.6), $f_{photorespi}$ (0.3) and f_{Mehler} (0.1) and varied the fractions as indicated in Table S5 (tests 0, 1 and 2).

In addition, we did other tests for uncertainties in the values of the fractionation coefficient of photorespiration given by Helman et al. (2005) (test 3 in grey columns of Tables S5, S6 and S7). The initial values for photorespiration isotopic discrimination are respectively -21.3 ‰ and -11.07 ‰ for $^{18}\varepsilon_{photo\_respi}$ and $^{17}\varepsilon_{photo\_respi}$ as given by Helman et al. (2005). From uncertainties on these values of 0.5 ‰ and 0.3 ‰ for $^{18}\varepsilon_{photo\_respi}$ and $^{17}\varepsilon_{photo\_respi}$ (Helman et al., 2005), we used alternative values of -20.8 ‰ and -11.04 ‰ for $^{18}\varepsilon_{photo\_respi}$ and $^{17}\varepsilon_{photo\_respi}$. For the Mehler reaction we also chose the value proposed by Helman et al. (2005): $^{18}\varepsilon_{Mehler} = $ -10.8 ‰ and $^{17}\varepsilon_{Mehler} = $ -5.7 ‰. We did not test the uncertainty on fractionation coefficients of the Mehler reaction as given by Helman et al. (2005), because the uncertainties are very small.

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79 **Table S4. Details of input parameters for sensitivity tests. White columns detail the tests on the**
80 **fractions of oxygen consumption and isotopic discriminations; grey column details the test on the**
81 **values of isotopic discrimination.**

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	Test 0	Test 1	Test 2	Test 3
f_{dark_respi}	1	0.9	0.4	0.6
f_{photo_respi}	0	0	0.5	0.3
f_{Mehler}	0	0.1	0.1	0.1
$^{18}\varepsilon_{photo\_respi}$	-21.3	-21.3	-21.3	-20.8
$^{17}\varepsilon_{photo\_respi}$	-11.07	-11.07	-11.07	-11.04

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91 **Table S5. α_{total_respi} values obtained from the sensitivity tests: results of sensitivity tests on**
92 **dioxygen consumption fractions (white columns) and on uncertainties in fractionation coefficient**
93 **values (grey column).** μ is the average over all lines above of the different quantities and σ the
94 associated standard deviation. The missing data are due to a problem during measurements.

Sequence	Period	$^{18}\alpha_{total\_respi0}$ Test 0	$^{18}\alpha_{total\_respi1}$ Test 1	$^{18}\alpha_{total\_respi2}$ Test 2	$^{18}\alpha_{total\_respi3}$ Test 3	$^{17}\alpha_{total\_respi0}$ Test 0	$^{17}\alpha_{total\_respi1}$ Test 1	$^{17}\alpha_{total\_respi2}$ Test 2	$^{17}\alpha_{total\_respi3}$ Test 3
1	1	0.9868	0.9870	0.9830	0.9847	0.9933	0.9934	0.9912	0.9921
	2	0.9865	0.9868	0.9829	0.9846	0.9933	0.9934	0.9912	0.9921
	3	0.9871	0.9873	0.9831	0.9849	0.9935	0.9936	0.9913	09922
	4	0.9859	0.9862	0.9826	0.9842	0.9926	0.9927	0.9909	0.9917
2	1	0.9828	0.9835	0.9814	0.9824	0.9913	0.9916	0.9904	0.9909
	2	0.9781	0.9792	0.9795	0.9795	0.9913	0.9916	0.9904	0.9909
	3	0.9834	0.9839	0.9816	0.9827				
3	1	0.9827	0.9833	0.9813	0.9822	0.9916	0.9919	0.9908	0.9911
	2	0.9797	0.9806	0.9801	0.9805	0.9892	0.9897	0.9898	0.9897
	3	0.9879	0.9880	0.9834	0.9854	0.9938	0.9939	0.9917	0.9924
μ		0.9838	0.9843	0.9818	0.9829	0.9922	0.9924	0.9909	0.9914
σ		0.0031	0.0028	0.0013	0.0019	0.0014	0.0013	0.00055	0.0008

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98 **Table S6.** $\alpha_{photosynthesis}$ **values obtained from the sensitivity tests: results of sensitivity tests on**
99 **dioxygen consumption fractions (white columns) and on uncertainties in fractionation coefficient**
100 **values (grey column).** μ is the average over all lines above of the different quantities and σ the
101 associated standard deviation.

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Sequence	Period	$^{18}\alpha_{photosynthesis0}$ Test 0	$^{18}\alpha_{photosynthesis0}$ Test 1	$^{18}\alpha_{photosynthesis0}$ Test 2	$^{18}\alpha_{photosynthesis0}$ Test 3	$^{17}\alpha_{photosynthesis0}$ Test 0	$^{17}\alpha_{photosynthesis0}$ Test 1	$^{17}\alpha_{photosynthesis0}$ Test 2	$^{17}\alpha_{photosynthesis0}$ Test 3
1	1	0.9941	0.9944	0.9951	0.9969	0.9969	0.9970	0.9974	0.9972
	2	1.0040	1.0040	1.0036	1.0038	1.0020	1.0020	1.0018	1.0019
	3	1.0039	1.0039	1.0034	1.0037	1.0017	1.0017	1.0015	1.0016
2	1	1.0021	1.0023	1.0023	1.0024	1.0013	1.0014	1.0013	1.0013
	2	1.0043	1.0044	1.0040	1.0043	1.0021	1.0021	1.0019	1.0020
3	1	1.0037	1.0039	1.0039	1.0040	1.0096	1.0021	1.0021	1.0021
	2	1.0019	1.0022	1.0026	1.0024	1.0013	1.0014	1.0016	1.0014
	3	1.0063	1.0066	1.0056	1.0062	1.0034	1.0035	1.0030	1.0035
μ		1.0026	1.0027	1.0026	1.0030	1.0023	1.0014	1.0013	1.0013
σ		0.0039	0.0034	0.0030	0.0025	0.0033	0.0018	0.0016	0.0017

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105 **Table S7. Complete data set of the different average photosynthesis coefficient fractionations of**
106 **oxygen during light periods during the photosynthesis and respiration experiment.**
107 μ is the average over all lines above of the different quantities and σ the associated standard deviation.

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Sequence	Period	$^{18}\alpha_{photosynthesis}$	$^{17}\alpha_{photosynthesis}$	$\gamma_{photosynthesis}$
1	1	0.9947	0.9972	0.5296
	2	1.0038	1.0019	0.5067
	3	1.0037	1.0016	0.4420
2	1	1.0023	1.0013	0.5672
	2	1.0043	1.0020	0.4794
3	1	1.0039	1.0020	0.5202
	2	1.0024	1.0014	0.6047
	3	1.0061	1.0032	0.5248
μ		1.0027	1.0013	0.5218
σ		0.0032	0.0017	0.0498

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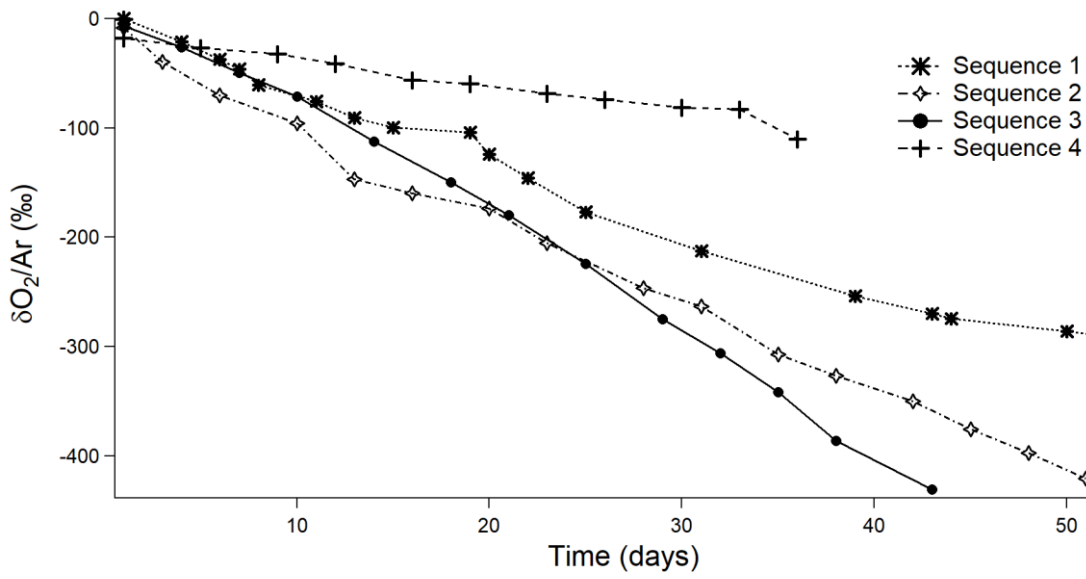
Fig.S1. Comparison of the evolution of the O₂ concentration of the sequence 1, 2, 3 and 4 during
the soil respiration experiment.

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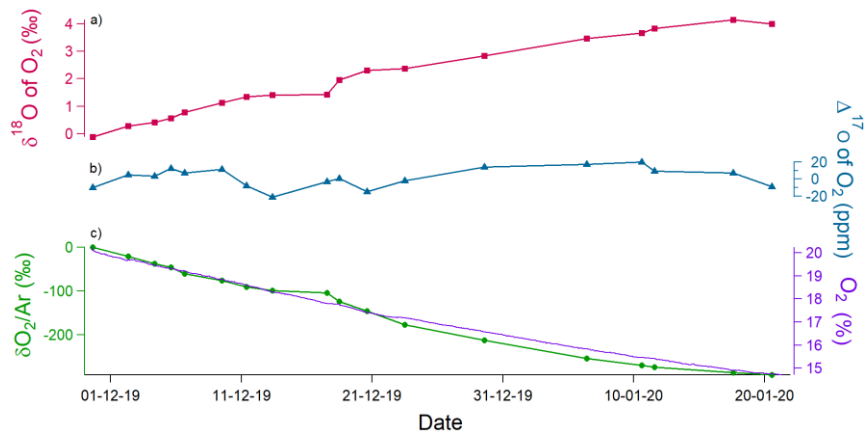
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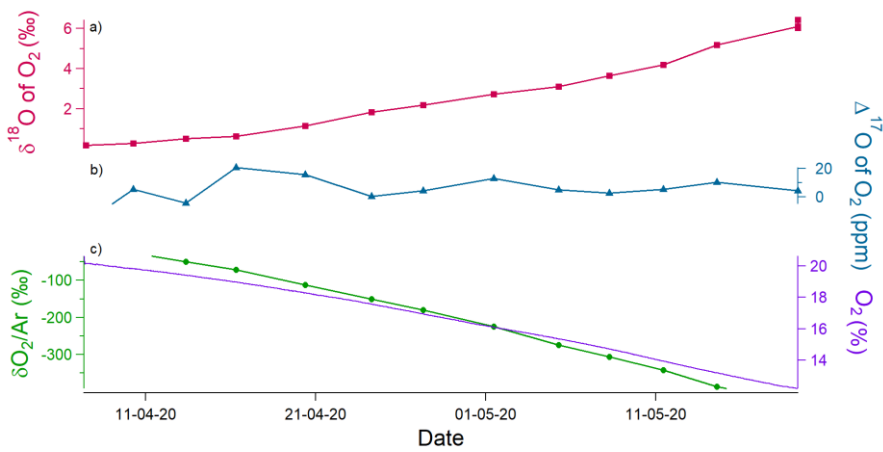
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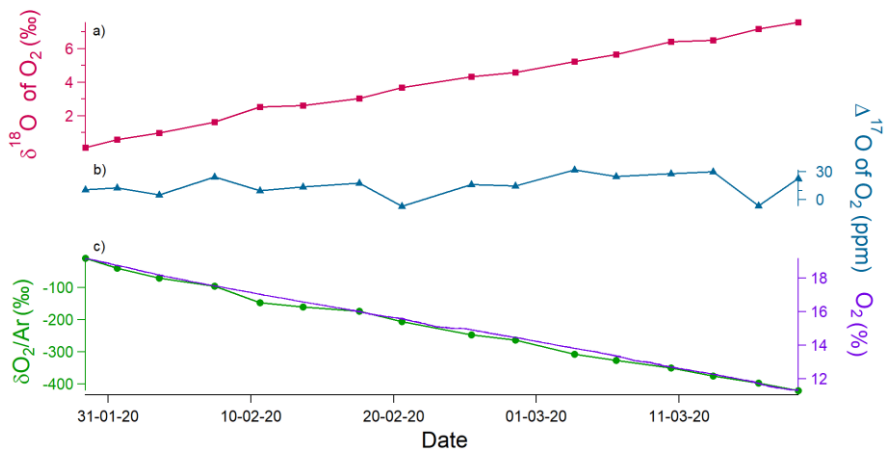
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124   **Fig.S2. Summary of the first (1), third (2) and fourth (3) sequences of the soil respiration experiment.**
125   **(a) $\delta^{18}O$ of O_2 (red) variations. (b) $\Delta^{17}O$ of O_2 (blue) variations. (c) Dioxygen (purple) and $\delta O_2/Ar$**
126   **variations (green).**

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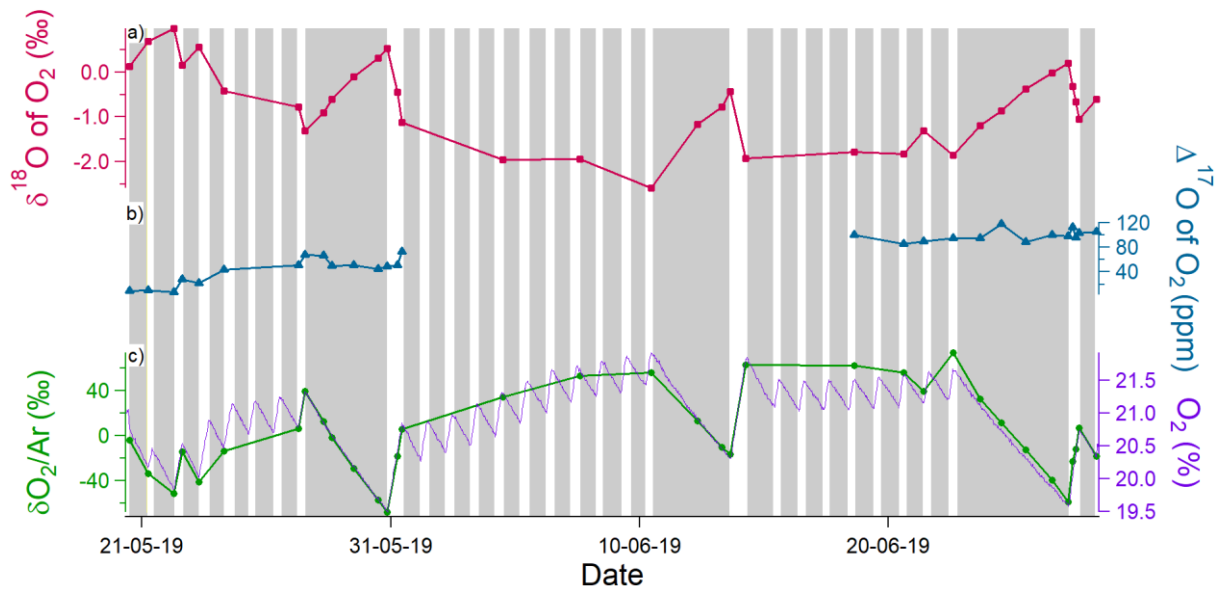
129   **1)**

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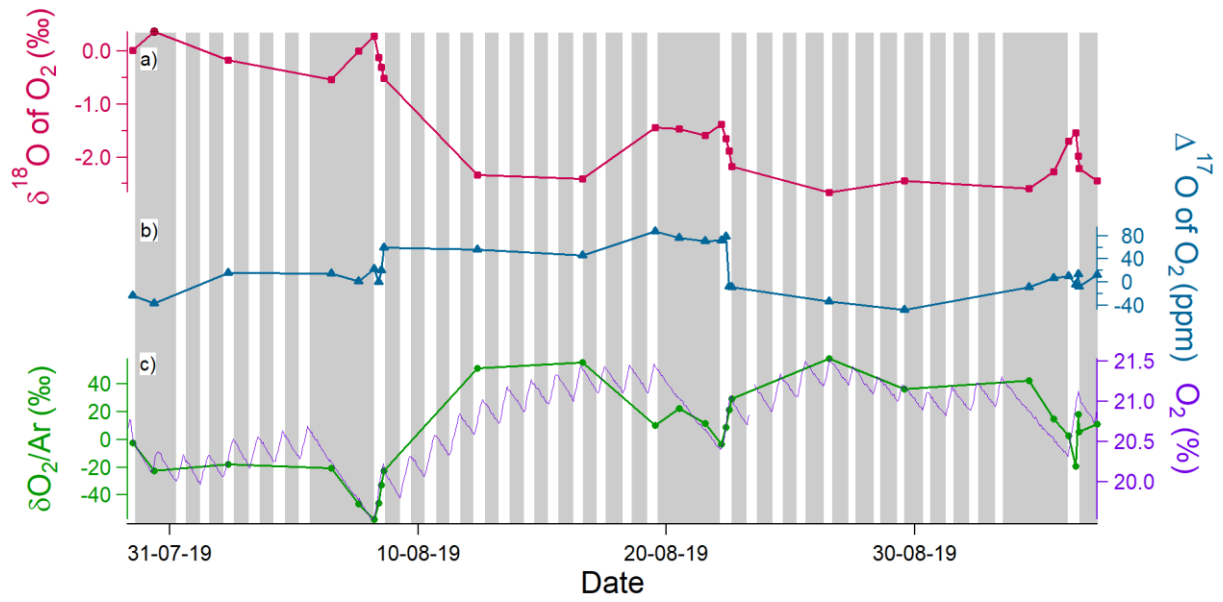
138 **Fig.S3. Summary of the second (1) and third (2) sequences of the soil respiration experiment. Grey**
139 **rectangles correspond to night periods and white rectangles to light periods. (a) δ¹⁸O of O₂ (red)**
140 **variations. (b) Δ¹⁷O of O₂ (blue) variations. (c) Dioxygen concentration (purple) and δO₂/Ar variations**
141 **(green).**