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Supplement of

Oxygen isotope exchange between water and carbon dioxide in soils is controlled by pH, nitrate and microbial biomass through links to carbonic anhydrase activity

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Supplementary Tables

Table S1: *Ranking and included terms for a subset of the generalised linear models tested to predict variations in the rate of oxygen isotope exchange, k_{iso}, for the entire dataset (n = 44). Model selection was limited to a maximum of four predictive terms and the intercept. The terms MB, NO_3^- and NH_4^+ are the natural logarithms of microbial biomass and exchangeable nitrate and exchangeable ammonium. Selected terms or interactions within each model are indicated by + symbols whilst - symbols indicate their omission. The interactions Campaign:pH and Campaign:MB are omitted from the table for brevity as they were not selected in any of the models shown. Model ranking was based on comparison of sample size corrected Aikake's Information Criterion (AICc) with ΔAICc indicating the difference in AICc from the best model. ΔAICc of 2 or more indicates real differences in model performance.*

Rank	Intercept	Campaign	pH	MB	NO_3^-	NH_4^+	Campaign: NO_3^-	pH: MB	pH: NO_3^-	MB: NO_3^-	$NO3^-$: NH_4^+	ΔAICc
1	+	-	+	+	+	-	-	-	+	-	-	0.00
2	+	-	+	+	+	-	-	-	-	-	-	6.10
3	+	+	+	+	+	-	-	-	-	-	-	7.06
4	+	-	+	+	+	-	-	+	-	-	-	7.07
5	+	+	+	-	+	-	+	-	-	-	-	7.09
6	+	-	+	+	+	-	-	-	-	+	-	8.79
7	+	+	+	-	+	-	-	-	-	-	-	12.43
8	+	-	-	+	+	+	-	-	-	-	+	13.27
16	+	-	+	-	-	-	-	-	-	-	-	21.56
19	+	-	-	-	-	+	-	-	-	-	-	26.48
21	+	-	-	+	-	-	-	-	-	-	-	43.64
28	+	-	-	-	-	-	-	-	-	-	-	47.91
33	+	+	-	-	-	-	-	-	-	-	-	50.15
34	+	-	-	-	+	-	-	-	-	-	-	50.21

Table S2: *Ranking and included terms for a subset of the generalised linear models tested to predict variations in the rate of oxygen isotope exchange, k_{iso}, for the relatively invariant soil properties of the EUR campaign dataset (n = 27). Model selection was limited to a maximum of two predictive terms and the intercept. The terms C, N and CN are soil carbon and nitrogen content and their ratio. Selected terms within each model are indicated by + symbols whilst - symbols indicate their omission. Model ranking was based on comparison of sample size corrected Aikake's Information Criterion (AICc) with ΔAICc indicating the difference in AICc from the best model. ΔAICc of 2 or more indicates real differences in model performance.*

Rank	Intercept	pH	Sand	Silt	Clay	C	N	CN	ΔAICc
1	+	+	-	-	+	-	-	-	0.00
2	+	+	+	-	-	-	-	-	0.57
3	+	+	-	-	-	+	-	-	1.32
4	+	+	-	-	-	-	-	-	1.85
5	+	+	-	-	-	-	-	+	1.92
6	+	+	-	+	-	-	-	-	2.46
7	+	+	-	-	-	-	+	-	4.57
8	+	-	-	-	-	-	+	-	21.26
9	+	-	-	-	-	-	-	-	22.07

Table S3: *Ranking and included terms for a subset of the generalised linear models tested to predict variations in the fractional change in rate of oxygen isotope exchange, k_{iso}, following ammonium nitrate addition (n = 15). Model selection was limited to a maximum of one predictive term and the intercept. The terms MB, NO_3^- and NH_4^+ are fractional changes in microbial biomass and exchangeable nitrate and ammonium following ammonium nitrate addition whilst the prefix ln indicates the natural logarithm of these changes. Selected terms within each model are indicated by + symbols whilst - symbols indicate their omission. Model ranking was based on comparison of sample size corrected Aikake's Information Criterion (AICc) with ΔAICc indicating the difference in AICc from the best model. ΔAICc of 2 or more indicates real differences in model performance.*

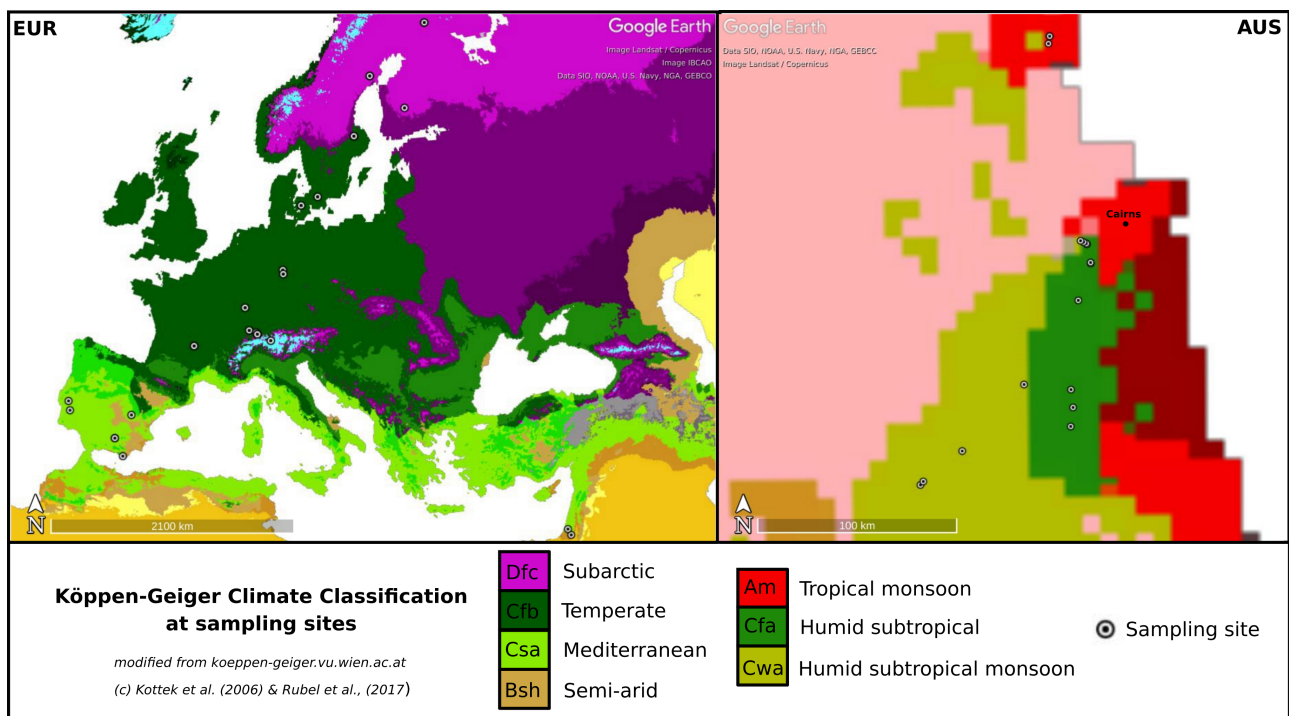| Rank	Intercept	Campaign	pH	MB	NO_3^-	NH_4^+	lnMB	$lnNO_3^-$	$lnNH_4^+$	ΔAICc
1	+	-	-	-	-	-	-	+	-	0.00
2	+	-	-	-	+	-	-	-	-	8.65
3	+	-	+	-	-	-	-	-	-	13.20
4	+	-	-	-	-	-	-	-	-	15.95
5	+	+	-	-	-	-	-	-	-	17.38
6	+	-	-	-	-	-	+	-	-	18.34
7	+	-	-	+	-	-	-	-	-	18.80
8	+	-	-	-	-	-	-	-	+	19.10
9	+	-	-	-	-	+	-	-	-	19.21

Supplementary Figures

Figure S1: *Location and climate of the 44 sites sampled; a) points indicating the location of the 27 sites in western Eurasia (EUR) within subartctic (Dfc; n= 6), temperate oceanic (Cfb; n= 13), hot-summer Mediterraean (Csa; n = 7) and hot semi-arid (Bsh; n = 1) climate zones, and b) points indicating the location of the 17 sites in north Queensland, Australia (AUS) within tropical monsoon (Am; n = 3), humid subtropical (Cfa; n = 9) and monsoon-influenced humid subtropical (Cwa; n= 5) climate zones. © Google Earth*
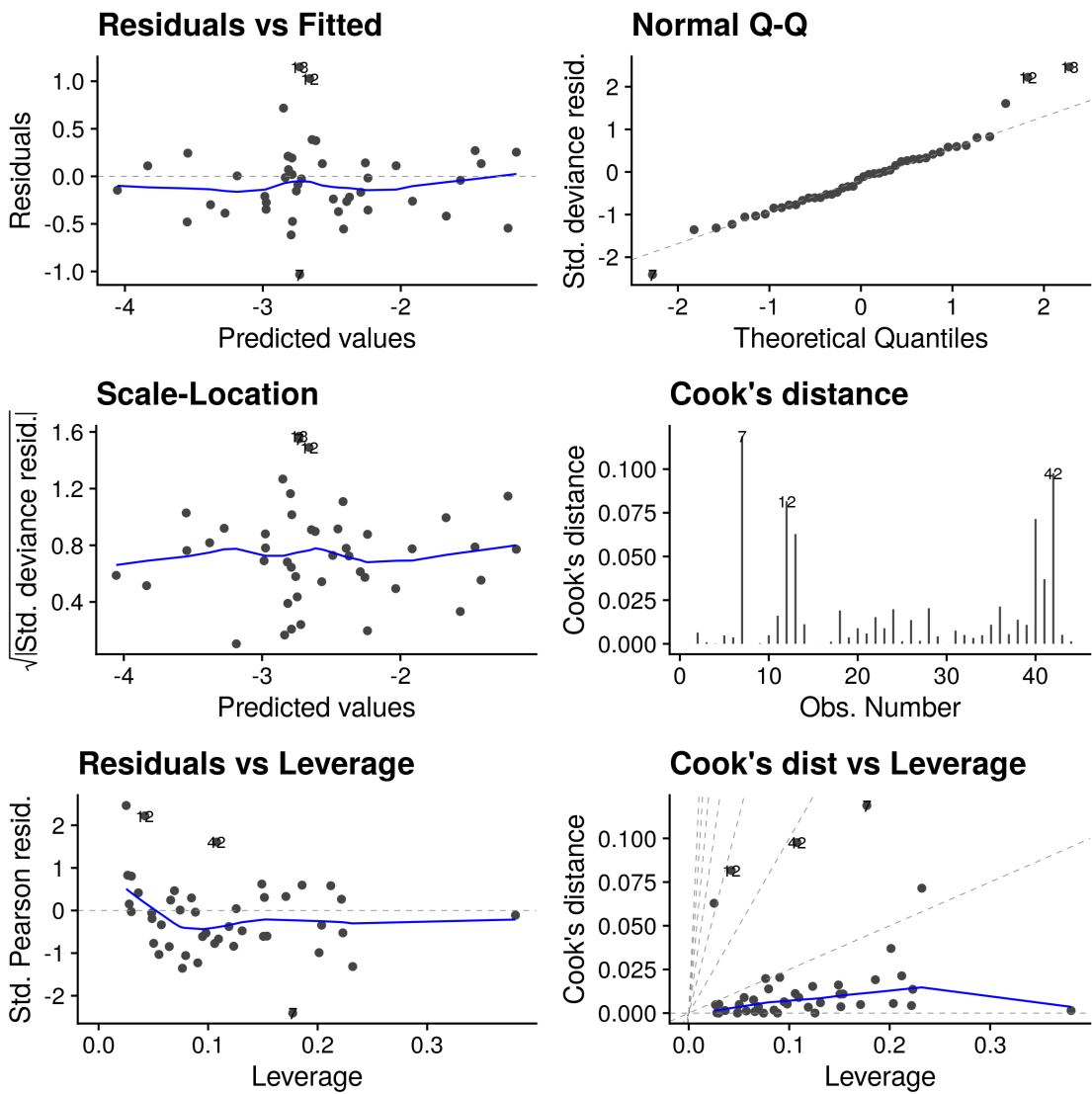
Figure S2: *Diagnostic plots for the minimal adequate model describing variations in the exchange rate across the 44 sites sampled (Eq. 6).*
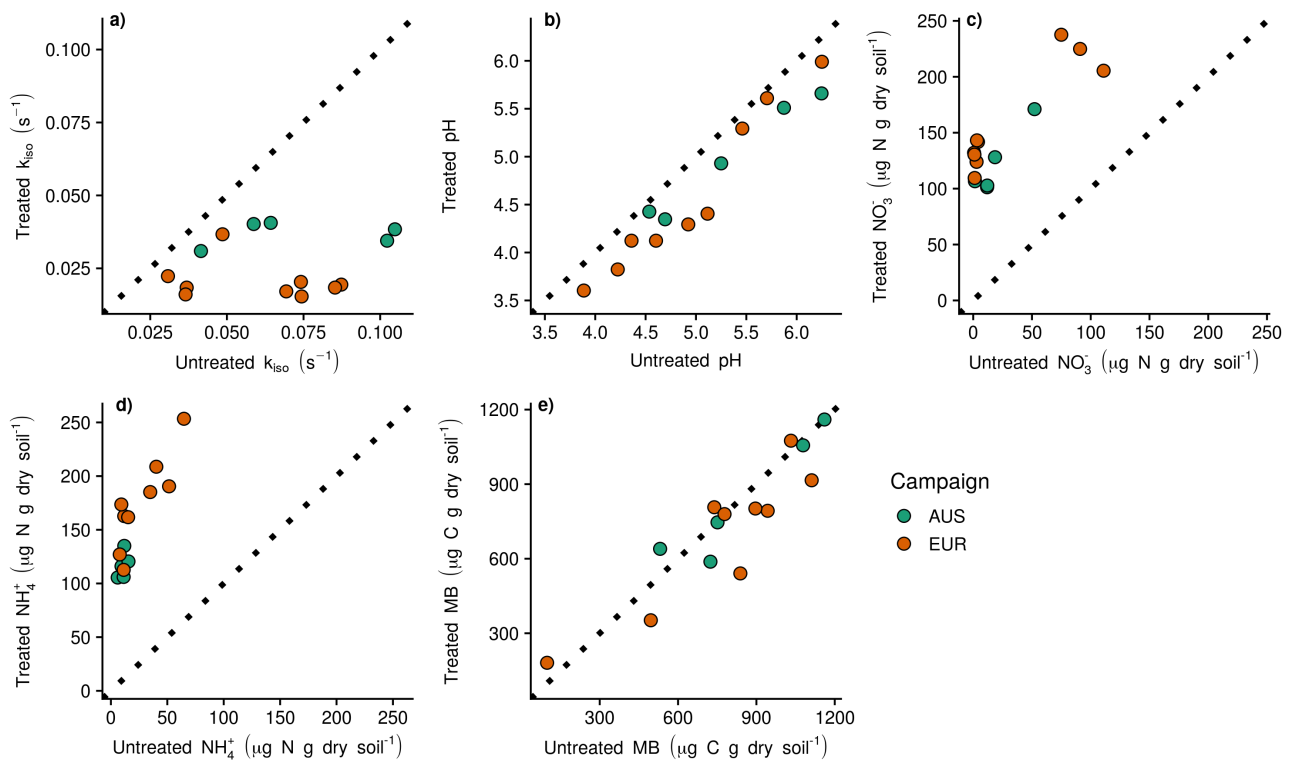
Figure S3: *Mean a) k_{iso}, b) pH, c) exchangeable nitrate (NO_3^-), d) exchangeable ammonium (NH_4^+) and e) microbial biomass (MB) for the untreated control and the corresponding treated soils studied as part of the ammonium nitrate addition experiment. Dashed lines indicating the 1:1 line with points below the line representing a decrease in treated relative to untreated soils and points above the line representing an increase. Points falling along the line indicate no change.*