Supplementary Tables STOTEN-27089
Modelling study of soil C, N and pH response to air pollution and climate change using European LTER site observations

Holmberg, M., Aherne, J., Austnes, K., Beloica, J., De Marco, A., Dirnböck, T., Fornasier, M.F., Goergen, K., Futter, M., Lindroos, A.-J., Krám, P., Neirynck, J., Nieminen, T.M., Pecka, T., Posch, M., Pröll, G., Rowe, E.C., Scheuschner, T., Schlutow, A., Valinia, S., Forsius, M.

Table of contents:

Supplementary Table A1. Site characteristics of 26 sites for which the VSD+ model was applied

Country	Site Code for VSD+ study	Site	Longitude (decimal coord.)	Latitude (decimal coord.)	Altitude (m a.s.l)	Networks[1]	ILTER Biome	Biogeographic region	Soils
Austria	AT01	Zöbelboden IP1	14.44	47.84	895	IM, LTER	Mixed forest	Alpine	Chromic Cambisols and hydromorphic Stagnosols
Austria	AT09	Klausen-Leopoldsdorf	16.05	48.12	510	FO, LTER	Deciduous Forest	Alpine	Endostagnic Endoskeletic Luvisol
Austria	AT16	Murau	14.11	47.06	1540	FO, LTER	Evergreen Forest	Subalpine	Hyperdystric Endoskeletic Cambisol
Belgium	BE001	Brasschaat	4.52	51.31	14	FO, LTER	Evergreen Forest	Atlantic	Moderately wet and sandy Arenosol with distinct horizons of humus and iron, forest floor mor-moder type
Germany	DE01	Forellenbach	13.42	48.94	894	IM, LTER	Deciduous Forest	Continental	Dystric Cambisol
Germany	DE02	Neuglobsow	13.03	53.13	65	IM	Mixed forest	Continental	Eutric Cambisol
Germany	DE301	Lüss	10.28	52.84	125	FO, LTER	Deciduous Forest	Atlantic	Albic Rustic Podzol
Germany	DE507	Monschau	6.15	50.4	445	FO, LTER	Deciduous Forest	Atlantic	Dystric Cambisol
Finland	FI01	Valkea-Kotinen	25.06	61.24	165	IM, FO, LTER	Taiga	Boreal	Cambic Podzol
Finland	FI03	Hietajärvi	30.68	63.15	170	IM, FO	Taiga	Boreal	Haplic Podzol
United Kingdom	GB54	Wytham	-1.33	51.77	138	LTER	Deciduous	Atlantic	Eutric Vertic Stagnosols
United Kingdom	GB55	Alice Holt	-0.85	51.17	125	IM, FO, LTER	Deciduous	Atlantic	Eutric Vertic Stagnosols
Italy	IT05	Selva Piana	13.59	41.85	1500	IM, FO, LTER	Deciduous Forest	Alpine	Orthic Rendzinas
Italy	IT07	Carrega	10.2	44.73	200	IM, FO	Deciduous Forest	Continental	Plano-Gleyic Luvisols
Italy	IT08	Brasimone	11.12	44.11	975	IM, FO	Deciduous Forest	Continental	Calcaric Regosols
Italy	IT09	Monte Rufeno	11.9	42.83	690	IM, FO, LTER	Deciduous Forest	Mediterranean	Calcaric Regosols
Italy	IT10	Val Masino	9.55	46.24	1190	IM, FO, LTER	Evergreen Forest	Alpine	Dystrict Lithosols
Norway	NO01	Birkenes	8.25	58.38	190	IM, FO, LTER	Taiga	Boreal	Podzol and Cambisol
Poland	PL01	Puszcza Borecka	22.05	54.12	170	IM	Deciduous forest	Continental	Luvisol

Poland	PLSNP	Słowiński National Park	17.47	54.7	15	FO, LTER	Evergreen Forest	Continental	Histo-Humic Gleysol
Poland	PLTNP	Tatrzański National Park	19.99	49.27	970	LTER	Evergreen Forest	Alpine	Calcaric Lithosol
Serbia	RS1	Kopaonik	20.81	43.29	1700	FO, LTER	Mixed forest	Continental	Cambic Podzol, Humic Cambisol
Serbia	RS2	Crni vrh	21.98	44.13	940	FO, LTER	Deciduous forest	Continental	Dystric Cambisol
Sweden	SE14	Aneboda	14.53	57.12	230	IM, LTER	Taiga	Boreonemoral	Podzol
Sweden	SE15	Kindla	14.9	59.75	345	IM, LTER	Taiga	Boreal	Podzol
Sweden	SE16	Gammtratten	18.1	63.86	425	IM, LTER	Taiga	Boreal	Podzol and Histosol

[1] Networks:
FO (UNECE ICP Forests, International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests under the United Nation's Economic Commission for Europe);
IM (UNECE ICP IM, International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Ecosystems under the United Nation's Economic Commission for Europe);
LTER (LTER Europe, International Long Term Ecological Research regional network for Europe)

Supplementary Table A2. List of combinations of RCP – GCM – RCM -bias adjustment and reference data in the 24 ensemble members used in the study. For each model combination air temperature and precipitation are available bias adjusted; global radiation is based on the same RCP – GCM – RCM combination, albeit not bias adjusted. The naming is based on the official CORDEX data protocol data reference syntax controlled vocabulary. Using these identifiers data can be found on any ESGF data node (e.g., https://esgf-node.ipsl.upmc.fr/projects/esgf-ipsl/). The table is sorted according to driving GCM and CMIP5 experiment name. Meaning of the bias adjustment methods: DBS45, distribution based scaling from Swedish Meteorological and Hydrological Institute (SMHI) (Yang et al., 2010); CDFT21, cumulative distribution function from Institut Pierre Simon Laplace (IPSL) (Vrac et al., 2016). Meaning of the bias adjustment calibration datasets: MESAN, regional reanalysis (from EU FP7 EURO4M project) from SMHI (Landelius et al., 2016); WFDEI, WATCH forcing data methodology applied to ERA-Interim (from FP6 WATCH project) (Weedon et al., 2014). Overall six different bias adjustment schemes and three different calibration datasets have been applied to the CORDEX RCMs by different institutions.

Combination identifier (Fig. 4)	GCM model name, institute identifier and model identifier	CMIP5 experiment name (ensemble member not mentioned)	Institution which ran RCM	RCM model name and version	RCM model run version	Institution that did bias adjustment	Bias adjustment method	Bias adjustment calibration dataset	Time span over which bias adjustment calibrated
A	CNRM-CERFACS-CNRM-CM5	RCP45 / RCP85	CLMcom	CCLM4-8-17	v1	SMHI	DBS45	MESAN	1989-2010
B	CNRM-CERFACS-CNRM-CM5	RCP45 / RCP85	CNRM	ARPEGE51	v1	IPSL	CDFT21	WFDEI	1979-2005
C	CNRM-CERFACS-CNRM-CM5	RCP45 / RCP85	SMHI	RCA4	v1	IPSL	CDFT21	WFDEI	1979-2005
D	ICHEC-EC-EARTH	RCP45 / RCP85	KNMI	RACMO22E	v1	IPSL	CDFT21	WFDEI	1979-2005
E	IPSL-IPSL-CM5A-MR	RCP45 / RCP85	IPSL-INERIS	WRF331F	v1	IPSL	CDFT21	WFDEI	1979-2005
F	IPSL-IPSL-CM5A-MR	RCP45 / RCP85	SMHI	RCA4	v1	IPSL	CDFT21	WFDEI	1979-2005
G	MOHC-HadGEM2-ES	RCP45 / RCP85	CLMcom	CCLM4-8-17	v1	SMHI	DBS45	MESAN	1989-2010
H	MOHC-HadGEM2-ES	RCP45 / RCP85	KNMI	RACMO22E	v2	SMHI	DBS45	MESAN	1989-2010
I	MOHC-HadGEM2-ES	RCP45 / RCP85	SMHI	RCA4	v1	IPSL	CDFT21	WFDEI	1979-2005
J	MPI-M-MPI-ESM-LR	RCP45 / RCP85	CLMcom	CCLM4-8-17	v1	SMHI	DBS45	MESAN	1989-2010
K	MPI-M-MPI-ESM-LR	RCP45 / RCP85	MPI-CSC	REMO2009	v1	SMHI	DBS45	MESAN	1989-2010
L	MPI-M-MPI-ESM-LR	RCP45 / RCP85	SMHI	RCA4	v1	IPSL	CDFT22	WFDEI	1979-2005

Landelius, T., Dahlgren, P., Gollvik, S., Jansson, A., Olsson, E., 2016. A high-resolution regional reanalysis for Europe. Part 2: 2D analysis of surface temperature, precipitation and wind. Q. J. R. Meteorol. Soc. 142, 2132–2142. doi:10.1002/qj.2813
Vrac, M., Noël, T., Vautard, R., 2016. Bias correction of precipitation through Singularity Stochastic Removal: Because occurrences matter. J. Geophys. Res. Atmos. 121, 5237–5258. doi:10.1002/2015JD024511
Weedon, G.P., Balsamo, G., Bellouin, N., Gomes, S., Best, M.J., Viterbo, P., 2014. The WFDEI meteorological forcing data set: WATCH Forcing Data methodology applied to ERA-Interim reanalysis data. Water Resour. Res. 50, 7505–7514. doi:10.1002/2014WR015638
Yang, W., Andréasson, J., Phil Graham, L., Olsson, J., Rosberg, J., Wetterhall, F., 2010. Distribution-based scaling to improve usability of regional climate model projections for hydrological climate change impacts studies. Hydrol. Res. 41, 211. doi:10.2166/nh.2010.004

Supplementary Table A3. Summary of data used in calibration of VSD+. Number and year of observations.

	BS		C:N		pH		$[SO_4]$		$[NO_3]$		$[NH_4]$		[Bc] [1]	
Site	N	years	N	years	N	years	N	years	N	years	N	years	N	years
AT01	1	2004	1	2004	15	1998 - 2012	15	1998 - 2012	15	1998 - 2012	-	-	-	-
AT09	1	2008	1	2008	15	1998 - 2012	15	1998 - 2012	15	1998 - 2012	-	-	-	-
AT16	1	2008	1	2008	14	1998 - 2011	14	1998 - 2011	14	1998 - 2011	-	-	-	-
BE001	1	2004	1	2004	24	1992 - 2015	24	1992 - 2015	24	1992 - 2015	-	-	24	1992 - 2015
DE01	1	2010	2	1990; 2011	22	1991 -2012	-	-	-	-	-	-	-	-
DE02	2	2005; 2010	3	2005 - 2013	1	2005	-	-	-	-	-	-	-	-
DE301	1	2007	1	2007	6	1996 - 2001	-	-	-	-	-	-	-	-
DE507	1	2007	1	2007	6	1996 - 2001	-	-	-	-	-	-	-	-
FI01	1	1988	1	2006	5	2002 - 2006	3	2002 - 2006	3	2002 - 2006	3	2002 - 2006	3	2002 - 2006
FI03	1	1988	1	2006	5	2002 - 2006	5	2002 - 2006	5	2002 - 2006	5	2002 - 2006	5	2002 - 2006
GB54	-	-	5	1993 - 2013	5	1993 - 2013	-	-	-	-	-	-	-	-
GB55	-	-	5	1994 - 2014	5	1994 - 2014	-	-	-	-	-	-	-	-
IT05	1	2006	1	2006	1	1999	-	-	-	-	-	-	-	-
IT07	1	2006	1	2006	1	2006	-	-	-	-	-	-	-	-
IT08	1	2006	1	2006	1	2006	-	-	-	-	-	-	-	-
IT09	1	2006	1	2006	2	2006 - 2008	-	-	-	-	-	-	-	-
IT10	1	2006	1	2006	1	2006	-	-	-	-	-	-	-	-
NO01	1	1991	1	1991	22	1993 - 2014	-	-	22	1993 - 2014	22	1993 - 2014	-	-
PL01	1	1985	1	2004	5	1995 - 2013	-	-	5	1995 - 2013	-	-	-	-
PLTPN	1	2004	1	2004	3	1998 - 2012	-	-	-	-	-	-	-	-
PLSPN	1	2004	1	2004	3	1998 - 2012	-	-	-	-	-	-	-	-
RS1	1	2010	1	2010	1	2010	6	2011 - 2016	6	2011 - 2016	6	2011 - 2016	5	2012 - 2016
RS2	1	2013	1	2013	1	2013	9	2014 - 2016	9	2014 - 2016	9	2014 - 2016	9	2014 - 2016
SE14	1	2007	-	-	20	1994 - 2013	22	1994 - 2015	22	1994 - 2015	22	1994 - 2015	22	1994 - 2015
SE15	1	2007	-	-	20	1994 - 2013	22	1994 - 2915	22	1994 - 2915	22	1994 – 2915	22	1994 - 2915
SE16	1	2007	-	-	13	2000 - 2013	15	2000 - 2015	15	2000 - 2015	15	2000 - 2015	15	2000 - 2015

[1] $[Bc^{2+}]$ is the sum of Ca, Mg and K, where two K^+ ions are treated as one divalent ion.

Supplementary Table A4. Input VSD+ parameter values.

Site	Thickness (m)	Bulk density (g cm^{-3})	CO_2 pressure	Calcium in parent material (1)	Clay content (%)	CEC (meq kg^{-1})	Exchange model (2)	Organic acids model (3)	Parameters organic acids model (4)	Concentration of organic acids (mol m^{-3})
AT01	0.5	0.611	18	0.5	38.0	511.2	-	Mono-protic organic acid	4.5	0.320
AT09	0.59	1.099	19.2		43.0	68.5	Gaines-Thomas	Mono-protic organic acid	4.5	0.050
AT16	0.45	0.671	15.3		21.0	74.6	Gaines-Thomas	Mono-protic organic acid	2.8	0.066
BE001	0.8	1.450	23		5.0	15.0	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.062
DE01	0.7	1.410	15		3.0	36.2	Gapon	Mono-protic organic acid	4.5	0.500
DE02	0.8	1.300	15		2.3	30.6	Gapon	Mono-protic organic acid	0	0.250
DE301	0.8	1.293	15		5.5	70.3	Gapon	Mono-protic organic acid	0	0.500
DE507	0.8	1.196	15		27.2	93.0	Gapon	Mono-protic organic acid	0	0.500
FI01	0.435	0.954	33		5.3	46.8	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.004
FI03	0.435	1.342	33		1.0	6.8	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.004
GB54	0.4	1.149	33		80.0	222.2	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.004
GB55	0.4	1.149	33		60.0	279.7	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.004
IT05	0.2	0.871	19.5		26.0	166.5	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.010
IT07	0.6	1.063	24.3		21.0	125.2	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.010
IT08	0.42	1.269	22.7		30.0	123.8	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.010
IT09	0.53	1.183	24		25.0	178.8	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.010
IT10	0.53	0.905	20.2		15.0	197.5	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.010
NO01	0.4	0.654	33		10.0	311.0	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.065
PL01	1	1.300	30		25.0	250.0	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.005
PLSNP	0.7	1.300	33		5.0	30.0	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.004
PLTNP	0.5	1.300	33		5.0	60.0	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.004
RS1	0.8	0.768	20		16.7	351.8	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.050
RS2	0.8	1.190	20		13.3	533.9	Gaines-Thomas	Oliver model	0.96; 0.9; 0.039	0.050
SE14	0.8	0.819	4		27.8	21.3	Gaines-Thomas	Mono-protic organic acid	4.5	0.200
SE15	0.7	0.949	4		25.0	9.5	Gaines-Thomas	Mono-protic organic acid	8	0.050
SE16	0.8	0.819	4		21.9	7.1	Gaines-Thomas	Mono-protic organic acid	4.3	0.500

(1) For calceareous soils, fraction (0 - 1) of Ca in parent material: if 0 pure calcite; if 1 pure dolomite.
(2) Type of model used for cation exchange in non-calcareous soils.
(3) Type of model used for simulating dissociation of organic acids (Bonten et al.2016).
(4) Parameters for organic acid dissociation model.

Supplementary Table A5. MetHyd input and output

site	Albedo (1)	Theta_Sat (2)	Theta_FC (3)	Theta_1bar (4)	Theta_WP (5)	Sand_ct (6)	OrgC_ct (7)	Period of data (8)	rf_nit (9)	rf_denit (10)	rf_mi R (11)	Theta (12)	Percolation (13)	TempC (14)	Precip (15)
AT01	0.11	0.58	0.43	0.36	0.24	8.80	2.71	1997-2013	0.80	0.80	0.83	0.49	1.23	6.16	1.77
AT09	0.14	0.55			0.24	6.60	1.50	1985-2013	0.92	0.92	1.08	0.40	0.32	8.88	0.72
AT16	0.11	0.65			0.24	43.00	7.30	1985-2013	0.58	0.58	0.63	0.43	0.86	4.22	1.16
BE01								1930-2008	1.10	0.003	1.10				
DE01	0.14	0.56	0.31	0.21	0.08	62.00	0.20	1991-2012	0.74	0.01	0.40	0.32	0.46	5.80	0.97
DE02	0.14	0.42	0.10	0.06	0.02	90.44	0.80	1991-2012	1.06	0.00	0.50	0.11	0.10	7.90	0.60
DE301	0.14	0.45	0.15	0.10	0.04	84.88	1.33	1991-2012	1.01	0.00	0.20	0.13	0.17	8.58	0.70
DE507	0.14	0.50	0.35	0.30	0.20	11.75	2.12	1991-2012	1.02	0.04	0.20	0.35	0.37	8.93	0.98
FI01	0.11	0.55	0.33	0.25	0.14	65.80	0.31	1963-2015							
FI03	0.11	0.45	0.20	0.14	0.06	89.97	0.14	1971-2015							
GB54	0.14	0.52	0.46	0.40	0.28	10.00	3.31	1993-2012	0.49	0.15	0.73	0.38	0.12	9.94	0.73
GB55	0.14	0.52	0.46	0.40	0.28	15.00	2.64	1995-2012	0.50	0.17	0.79	0.39	0.22	10.73	0.83
IT05	0.14	0.59	0.41	0.35	0.23	31.00	3.54	1998-2011							
IT07	0.14	0.53	0.37	0.31	0.21	37.00	3.52	1998-2011							
IT08	0.14	0.48	0.33	0.28	0.19	34.00	1.45	1999-2010							
IT09	0.14	0.50	0.35	0.30	0.20	31.00	2.56	1998-2011							
IT10	0.11	0.58	0.35	0.26	0.12	55.00	1.31	1997-2008							
NO01								1993-2014	0.56	0.07	0.65	0.26	1.02	4.91	1.52
PL01	0.14	0.38	0.26	0.24	0.08			1993-2013	0.76	0.01	0.62	0.19	0.12	6.64	0.66
PLSNP	0.11	0.45	0.14	0.09	0.04	85.00	1.00	1960-2010	0.86	0.00	0.90	0.12	0.23	7.51	0.65
PLTNP	0.11	0.45	0.14	0.09	0.04	85.00	1.00	1960-2010	0.40	0.00	0.42	0.14	1.03	1.46	1.33
RS1	0.11	0.63	0.40	0.31	0.16	59.16	3.90	1990-2014	0.52	0.0001	0.55	0.34	0.47	3.98	0.99
RS2	0.11	0.49	0.29	0.23	0.13	43.58	2.17	1990-2014	0.59	0.00	0.65	0.22	0.20	7.01	0.79
SE14	0.11	0.60	0.43	0.38	0.28	38.84	7.00	1901-2013							
SE15	0.11	0.57	0.40	0.35	0.25	38.01	5.00	1901-2013							
SE16	0.11	0.60	0.42	0.36	0.26	44.43	7.00	1901-2013							

MetHyd inputs

1) Albedo (0 - 1) defaults: conifer 0.11, deciduous 0.14, grassland 0.22
2) Water content at saturation as a volume fraction (0-1), given or computed in MetHyd from soil properties
3) Water content at field capacity (pF 2.0) as a volume fraction (0-1), given or computed in MetHyd from soil properties
4) Water content at -1 bar (pF 3.0) as a volume fraction (0-1), given or computed in MetHyd from soil properties
5) Water content at wilting point (pF 4.2) as a volume fraction (0-1), given or computed in MetHyd from soil properties

6) Sand content of the soil (%)
7) Organic carbon content of the soil (%)
8) Period of meteorological data (monthly or daily values of air temperature, precipitation and radiation) used as input to MetHyd
In addition, MetHyd inputs include site longitude and latitude (Suppl Table A1), bulk density and clay content (%) of the soil (Suppl. Table A3)
MetHyd outputs read by VSD+, either as period average values, or as annual or monthly values
9) Reduction factor of nitrification rates due to moisture and temperatue (-)
10) Reduction factor of denitrification rates due to moisture and temperatue (-)
11) Reduction factor of mineralisation rates due to moisture and temperature (-)
12) Water content of the soil (m3 m3)
13) Precipitation surplus (m/yr)
14) Average temperature T (oC)
15) Precipitation P (m/yr)

Supplementary Table A6. Observed values (N=25) of soil base saturation (BS) at 24 sites, with corresponding modelled values.

Site Code	Observation year	Observed BS	Error of observation used in VSD+ Bayesian calibration	Modelled BS
AT01	2004	1.00	0.10	1.00
AT09	2008	0.25	0.07	0.29
AT16	2008	0.0034	0.001	0.01
BE001	2004	0.08	0.01	0.10
DE01	2010	0.48	0.05	0.42
DE02	2005	0.29	0.18	0.45
DE02	2010	0.48	0.05	0.46
DE301	2007	0.10	0.03	0.23
DE507	2007	0.09	0.01	0.08
FI01	1988	0.37	0.03	0.34
FI03	1988	0.40	0.04	0.35
IT05	2006	0.85	0.11	0.78
IT07	2006	0.43	0.08	0.37
IT08	2006	0.83	0.20	0.67
IT09	2006	0.36	0.13	0.19
IT10	2006	0.25	0.13	0.23
NO01	1991	0.40	0.04	0.22
PL01	1985	0.51	0.05	0.63
PLTPN	2004	0.25	0.11	0.02
PLSPN	2004	0.30	0.01	0.02
RS1	2010	0.07	0.01	0.10
RS2	2013	0.42	0.03	0.47
SE14	2007	0.12	0.03	0.12
SE15	2007	0.06	0.01	0.06
SE16	2007	0.08	0.02	0.01

Supplementary Table A7. Observed values (N=34) of soil carbon to nitrogen ration (C:N) at 23 sites, with corresponding modelled values.

Site Code	Observation year	Observed C:N	Observation error	Modelled C:N
AT01	2004	14.2	1.4	13.66
AT09	2008	9.3	0.9	9.72
AT16	2008	27.6	1.6	27.02
BE001	2004	23.0	1.6	19.20
DE01	1990	21.8	1.0	22.62
DE01	2011	21.7	1.5	20.86
DE02	2005	17.7	1.5	18.54
DE02	2010	15.4	1.5	18.30
DE02	2013	22.1	1.5	18.14
DE301	2007	26.0	0.1	26.03
DE507	2007	19.7	0.1	20.49
FI01	2006	21.6	1.0	22.08
FI03	2006	18.1	1.0	19.50
GB54	1993	9.7	1.0	10.87
GB54	1998	15.4	1.5	10.86
GB54	2003	10.3	1.0	10.85
GB54	2008	10.3	1.0	10.85
GB54	2013	11.7	1.2	10.86
GB55	1994	17.1	1.7	14.67
GB55	1999	16.0	1.6	14.54
GB55	2004	13.0	1.3	14.25
GB55	2009	13.5	1.4	14.08
GB55	2014	13.2	1.3	14.02
IT05	2006	12.9	0.8	15.86
IT07	2006	17.7	4.5	12.16
IT08	2006	17.0	4.0	12.74
IT09	2006	11.5	0.3	10.78
IT10	2006	14.5	3.4	16.02
NO01	1991	31.0	3.5	30.99
PL01	2004	12.0	0.5	10.83
PLTPN	2004	25.0	8.0	29.84
PLSPN	2004	22.0	9.0	19.22
RS1	2010	15.7	1.1	17.88
RS2	2013	11.1	0.5	11.57

Supplementary Table A8. Observed values (N=224) of soil solution pH at 26 sites, with corresponding modelled values.

Site Code	Observation year	Observed annual average pH	Observation error used in VSD+ Bayesian calibration routine	Modelled annual pH
AT01	1998	7.75	1.08	7.17
AT01	1999	7.53	0.44	7.17
AT01	2000	7.50	0.30	7.17
AT01	2001	7.79	0.25	7.17
AT01	2002	7.77	0.26	7.17
AT01	2003	6.78	2.47	7.17
AT01	2004	7.87	0.43	7.17
AT01	2005	7.79	0.20	7.17
AT01	2006	7.85	0.21	7.17
AT01	2007	8.06	0.24	7.17
AT01	2008	8.00	0.18	7.17
AT01	2009	7.84	0.19	7.17
AT01	2010	7.91	0.22	7.17
AT01	2011	7.86	0.17	7.17
AT01	2012	7.93	0.21	7.17
AT09	1998	6.92	0.35	7.02
AT09	1999	7.18	0.31	7.02
AT09	2000	7.26	0.25	7.02
AT09	2001	7.05	0.33	7.03
AT09	2002	7.62	0.37	7.02
AT09	2003	7.64	0.19	7.02
AT09	2004	7.41	0.37	7.02
AT09	2005	6.96	0.19	7.02
AT09	2006	7.06	0.08	7.03
AT09	2007	6.94	0.04	7.03
AT09	2008	7.30	0.10	7.03
AT09	2009	6.80	0.50	7.03
AT09	2010	6.99	0.69	7.03
AT09	2011	6.79	0.33	7.03
AT09	2012	6.88	0.30	7.03
AT16	1998	4.41	0.15	5.09
AT16	1999	4.37	0.11	5.04
AT16	2000	4.58	0.14	4.97
AT16	2001	4.63	0.23	4.93
AT16	2002	4.57	0.25	4.88
AT16	2003	4.46	0.26	4.81
AT16	2004	4.65	0.11	4.75
AT16	2005	4.97	0.02	4.70
AT16	2006	4.99	0.10	5.17
AT16	2007	5.02	0.05	5.13
AT16	2008	4.94	0.02	5.08
AT16	2009	5.23	0.26	5.01
AT16	2010	5.18	0.42	4.94
AT16	2011	5.39	0.26	4.90
BE001	1992	3.62	0.15	3.62
BE001	1993	3.54	0.18	3.65

BE001	1994	3.56	0.18	3.71
BE001	1995	3.48	0.16	3.76
BE001	1996	3.55	0.14	3.64
BE001	1997	3.63	0.16	3.59
BE001	1998	3.72	0.49	3.78
BE001	1999	3.93	0.57	3.75
BE001	2000	3.78	0.09	3.77
BE001	2001	3.83	0.09	3.86
BE001	2002	3.91	0.11	3.88
BE001	2003	3.83	0.09	3.75
BE001	2004	3.86	0.09	3.71
BE001	2005	3.92	0.10	3.70
BE001	2006	3.84	0.07	3.68
BE001	2007	3.67	0.11	3.73
BE001	2008	3.76	0.05	3.79
BE001	2009	3.81	0.12	3.83
BE001	2010	3.92	0.07	3.93
BE001	2011	3.95	0.06	3.91
BE001	2012	3.95	0.06	3.94
BE001	2013	4.02	0.19	3.89
BE001	2014	4.08	0.27	3.91
BE001	2015	4.07	0.12	3.95
DE01	1991	4.68	0.10	4.28
DE01	1992	4.74	0.10	4.30
DE01	1993	4.61	0.10	4.31
DE01	1994	4.50	0.10	4.35
DE01	1995	4.42	0.10	4.37
DE01	1996	4.45	0.10	4.37
DE01	1997	4.37	0.10	4.40
DE01	1998	4.70	0.10	4.42
DE01	1999	4.57	0.10	4.43
DE01	2000	4.57	0.10	4.44
DE01	2001	4.70	0.10	4.45
DE01	2002	4.63	0.10	4.45
DE01	2003	4.70	0.10	4.45
DE01	2004	4.81	0.10	4.43
DE01	2005	4.76	0.10	4.47
DE01	2006	4.80	0.10	4.50
DE01	2007	4.73	0.10	4.49
DE01	2008	4.83	0.10	4.51
DE01	2009	4.84	0.10	4.53
DE01	2010	4.81	0.10	4.49
DE01	2011	4.89	0.10	4.53
DE01	2012	4.86	0.10	4.53
DE02	2005	4.93	1.30	6.14
DE301	1996	4.15	0.26	4.08
DE301	1997	4.13	0.22	4.10
DE301	1998	4.14	0.22	4.12
DE301	1999	4.19	0.21	4.14
DE301	2000	4.24	0.18	4.17
DE301	2001	4.22	0.21	4.18
DE507	1996	4.15	0.26	4.12
DE507	1997	4.13	0.22	4.12
DE507	1998	4.14	0.22	4.13
DE507	1999	4.19	0.21	4.14

DE507	2000	4.24	0.18	4.15
DE507	2001	4.22	0.21	4.16
FI01	2002	4.69	1.50	4.60
FI01	2003	4.19	1.50	4.70
FI01	2004	4.62	1.50	4.78
FI01	2005	4.27	1.50	4.73
FI01	2006	4.43	1.50	4.76
FI03	2002	4.57	1.50	4.21
FI03	2003	4.41	1.50	4.38
FI03	2004	4.46	1.50	4.53
FI03	2005	4.25	1.50	4.31
FI03	2006	4.16	1.50	4.38
GB54	1993	5.84	0.58	5.35
GB54	1998	5.57	0.56	5.45
GB54	2003	5.24	0.52	5.54
GB54	2008	5.69	0.57	5.62
GB54	2013	5.44	0.54	5.69
GB55	1994	4.63	0.46	4.21
GB55	1999	4.66	0.47	4.32
GB55	2004	4.34	0.43	4.44
GB55	2009	4.25	0.42	4.55
GB55	2014	4.56	0.46	4.67
IT05	1999	6.38	0.47	6.16
IT07	2006	8.30	0.87	6.25
IT08	2006	6.21	0.33	4.42
IT09	2006	6.05	0.53	5.43
IT09	2008	5.15	0.76	5.45
IT10	2006	5.75	0.32	5.35
NO01	1993	4.20	0.20	4.12
NO01	1994	4.40	0.20	4.15
NO01	1995	4.30	0.20	4.18
NO01	1996	4.30	0.20	4.18
NO01	1997	4.30	0.20	4.19
NO01	1998	4.40	0.20	4.19
NO01	1999	4.30	0.20	4.20
NO01	2000	4.30	0.20	4.20
NO01	2001	4.30	0.20	4.21
NO01	2002	4.40	0.20	4.22
NO01	2003	4.40	0.20	4.22
NO01	2004	4.40	0.20	4.23
NO01	2005	4.40	0.20	4.23
NO01	2006	4.40	0.20	4.24
NO01	2007	4.40	0.20	4.24
NO01	2008	4.40	0.20	4.25
NO01	2009	4.40	0.20	4.26
NO01	2010	4.40	0.20	4.26
NO01	2011	4.40	0.20	4.27
NO01	2012	4.50	0.20	4.27
NO01	2013	4.50	0.20	4.27
NO01	2014	4.40	0.20	4.28
PL01	1995	5.10	0.30	5.48
PL01	1996	4.70	0.30	5.50
PL01	1997	5.30	0.30	5.52
PL01	2012	5.60	0.30	5.70
PL01	2013	5.70	0.30	5.70

PLTPN	1998	4.20	0.30	4.30
PLTPN	2004	4.50	0.30	4.30
PLTPN	2012	4.50	0.30	4.30
PLSPN	1998	4.60	0.20	4.30
PLSPN	2004	4.80	0.20	4.09
PLSPN	2012	4.80	0.20	4.16
RS1	2011	6.35	0.70	4.54
RS1	2012	5.87	0.75	4.55
RS1	2013	4.62	0.76	4.56
RS1	2014	5.60	0.52	4.58
RS1	2015	5.82	1.21	4.60
RS1	2016	5.48	0.62	4.61
RS2	2014	6.09	1.03	5.66
RS2	2015	6.42	0.86	5.66
RS2	2016	6.02	0.46	5.66
SE14	1994	4.69	0.51	4.31
SE14	1995	4.61	0.32	4.33
SE14	1996	4.56	0.22	4.31
SE14	1997	4.47	0.17	4.33
SE14	1998	4.59	0.16	4.37
SE14	1999	4.68	0.30	4.37
SE14	2000	4.67	0.30	4.38
SE14	2001	4.70	0.34	4.40
SE14	2002	4.71	0.30	4.40
SE14	2003	4.79	0.20	4.39
SE14	2004	4.75	0.24	4.42
SE14	2005	4.72	0.18	4.42
SE14	2006	4.74	0.24	4.43
SE14	2007	4.75	0.19	4.45
SE14	2008	4.85	0.26	4.46
SE14	2009	4.95	0.37	4.46
SE14	2010	4.85	0.23	4.47
SE14	2011	4.62	0.27	4.49
SE14	2012	4.81	0.30	4.50
SE14	2013	4.26	0.58	4.49
SE15	1994	4.60	0.14	4.16
SE15	1995	4.63	0.11	4.19
SE15	1996	4.66	0.07	4.17
SE15	1997	4.68	0.08	4.19
SE15	1998	4.62	0.14	4.23
SE15	1999	4.71	0.10	4.28
SE15	2000	4.73	0.09	4.35
SE15	2001	4.71	0.08	4.37
SE15	2002	4.74	0.11	4.36
SE15	2003	4.52	0.54	4.35
SE15	2004	4.60	0.31	4.41
SE15	2005	4.64	0.31	4.40
SE15	2006	4.69	0.22	4.44
SE15	2007	4.76	0.15	4.44
SE15	2008	4.80	0.15	4.50
SE15	2009	4.86	0.09	4.50
SE15	2010	4.92	0.08	4.50
SE15	2011	4.88	0.07	4.49
SE15	2012	4.91	0.11	4.54
SE15	2013	4.80	0.09	4.45

SE16	2000	5.19	0.26	5.12
SE16	2001	5.24	0.30	5.12
SE16	2002	5.18	0.27	5.12
SE16	2003	5.13	0.51	5.12
SE16	2004	4.97	0.55	5.12
SE16	2005	5.18	0.42	5.12
SE16	2007	5.14	0.44	5.13
SE16	2008	4.87	0.72	5.13
SE16	2009	5.16	0.72	5.13
SE16	2010	5.44	0.21	5.13
SE16	2011	5.11	0.44	5.13
SE16	2012	5.15	0.52	5.13
SE16	2013	4.94	0.76	5.13

Supplementary Table A9. Calibrated VSD+ parameter values.

Site	Initial C pool ($g\ m^{-2}$)	Initial C:N ($g\ g^{-1}$)	lgK_AlBc (1)	lgK_HBc (2)	lgK_Alox (3)	Initial BS (4)	Ca weathering ($eq\ m^3\ yr^{-1}$)	Mg weathering ($eq\ m^3\ yr^{-1}$)	K weathering ($eq\ m^3\ yr^{-1}$)	Na weathering ($eq\ m^3\ yr^{-1}$)
AT01	6015	5	-	-	6.15	-	10.000	10.000		
AT09	9000	8	16.43	2.57	8.90	-	0.468	0.304	0.309	
AT16	28000	23	6.82	3.47	8.00	-	0.010	0.010	0.100	
BE001	14657	35	-0.89	-1.09	7.46	-	0.010	0.001	0.001	0.003
DE01	7000	28	0.17	2.03	7.90	0.60	0.150	0.200	0.150	
DE02	27516	21	0.14	2.00	7.89	0.67	0.200	0.010	0.093	0.0004
DE301	10000	34	0.10	2.67	7.90	0.26	0.006	0.006	0.011	
DE507	10370	22	0.75	2.08	7.90	0.20	0.108	0.053	0.116	
FI01	1200	5	0.50	6.30	6.00	0.35	0.060	0.070	0.020	0.020
FI03	300	2	-5.00	1.00	7.00	0.45	0.025	0.008	0.008	0.008
GB54	11850	10	0.16	6.73	7.90	-	0.173	0.035	0.025	0.025
GB55	15032	18	0.16	6.73	7.90	-	0.294	0.148	0.025	0.025
IT05	4480	10	8.50	2.00	8.00	0.70	0.014	0.007	0.004	0.002
IT07	2000	15	12.00	3.00	8.00	0.60	0.055	0.022	0.014	0.024
IT08	8000	15	-5.00	0.21	8.00	0.60	0.011	0.004	0.005	0.049
IT09	14000	8	6.97	3.77	8.00	0.33	0.032	0.013	0.008	0.014
IT10	3033	20	4.26	2.53	8.00	0.34	0.023	0.009	0.006	0.010
NO01	10453	52	0.10	1.98	6.22	0.29	0.050	0.004	0.004	0.012
PL01	7000	8	3.00	7.00	6.00	0.40	0.800	0.100		
PLSNP	5093	25	0.001	0.07	7.90	0.10	0.005		0.001	0.001
PLTNP	6650	20	0.003	0.003	7.90	0.20	0.020		0.001	0.001
RS1	6358	10	5.02	2.21	6.00	0.07	0.083			
RS2	5793	10	0.30	2.08	8.00	0.46	0.100			
SE14	8000	25	0.16	3.80	7.90	0.20	0.020	0.030	0.010	0.010
SE15	10000	25	0.16	3.80	7.90	-	0.020	0.012	0.002	0.010
SE16	5000	25	0.16	4.00	7.90	0.10	0.020	0.010	0.001	0.010

(1) Log10 of selectivity constant for Al-Bc exchange
(2) Log10 of selectivity constant for H-Bc exchange
(3) Log10 of Al equilibrium constant ($(mol/l)^{-2}$)
(4) Initial base saturation. If missing, its value is determined by the model assuming equilibrium conditions at the start.

Supplementary Table A10. Observed values (N=171) of soil solution [NO_3^-] at 11 sites, with corresponding modelled values.

Site	Observation year	Observed annual average [NO_3^-] (μeq L^{-1})	Modelled annual [NO_3^-] (μeq L^{-1})
AT01	1998	66.68	7.80
AT01	1999	100.45	7.63
AT01	2000	66.87	7.48
AT01	2001	69.20	7.40
AT01	2002	37.35	7.34
AT01	2003	69.14	7.28
AT01	2004	48.56	7.21
AT01	2005	47.75	7.14
AT01	2006	45.66	7.24
AT01	2007	41.11	7.34
AT01	2008	65.24	7.43
AT01	2009	56.74	7.53
AT01	2010	39.99	7.64
AT01	2011	51.82	7.63
AT01	2012	61.44	7.63
AT09	1998	60.00	7.06
AT09	1999	70.00	6.90
AT09	2000	60.00	6.72
AT09	2001	30.00	6.65
AT09	2002	40.00	6.60
AT09	2003	80.00	6.52
AT09	2004	90.00	6.46
AT09	2005	40.00	6.39
AT09	2006	40.00	6.32
AT09	2007	20.00	6.22
AT09	2008	20.00	6.15
AT09	2009	50.00	6.07
AT09	2010	30.00	6.00
AT09	2011	50.00	5.88
AT09	2012	30.00	5.76
AT16	1998	140.00	1.37
AT16	1999	160.00	1.37
AT16	2000	140.00	1.35
AT16	2001	60.00	1.28
AT16	2002	40.00	1.22
AT16	2003	40.00	1.16
AT16	2004	20.00	1.08
AT16	2005	30.00	1.02
AT16	2006	20.00	0.95
AT16	2007	20.00	0.85
AT16	2008	20.00	0.78
AT16	2009	0.01	0.71
AT16	2010	40.00	0.65
AT16	2011	0.01	0.63
BE001	1992	1060.00	582.54
BE001	1993	1140.00	464.84
BE001	1994	840.00	284.64
BE001	1995	730.00	48.42

BE001	1996	1260.00	105.27
BE001	1997	970.00	128.34
BE001	1998	650.00	34.13
BE001	1999	260.00	57.72
BE001	2000	430.00	238.81
BE001	2001	380.00	39.76
BE001	2002	360.00	92.86
BE001	2003	410.00	178.49
BE001	2004	190.00	287.97
BE001	2005	250.00	333.01
BE001	2006	290.00	320.98
BE001	2007	440.00	158.82
BE001	2008	370.00	141.90
BE001	2009	240.00	79.54
BE001	2010	160.00	32.19
BE001	2011	120.00	40.67
BE001	2012	180.00	31.85
BE001	2013	110.00	39.29
BE001	2014	60.00	32.46
BE001	2015	90.00	30.85
FI01	2002	1.00	8.50
FI01	2004	0.00	2.94
FI01	2006	2.00	4.59
FI03	2002	0.40	6.92
FI03	2003	1.40	3.49
FI03	2004	0.40	2.06
FI03	2005	0.90	5.34
FI03	2006	1.70	3.88
NO01	1993	2.86	8.30
NO01	1994	1.52	7.90
NO01	1995	1.95	7.50
NO01	1996	1.02	7.40
NO01	1997	0.87	7.30
NO01	1998	1.59	7.20
NO01	1999	2.14	7.11
NO01	2000	1.43	7.01
NO01	2001	1.43	6.92
NO01	2002	2.14	6.82
NO01	2003	2.14	6.73
NO01	2004	2.14	6.63
NO01	2005	2.14	6.54
NO01	2006	2.14	6.39
NO01	2007	2.14	6.24
NO01	2008	2.14	6.09
NO01	2009	2.14	5.94
NO01	2010	2.14	5.79
NO01	2011	2.50	5.68
NO01	2012	2.14	5.58
NO01	2013	2.14	5.48
NO01	2014	2.14	5.37
PL01	1995	163.00	28.63
PL01	1996	141.00	27.70
PL01	1997	19.00	26.81
PL01	2012	5.00	23.38
PL01	2013	11.00	23.14

RS1	2011	316.00	12.426
RS1	2012	1058.00	12.158
RS1	2013	149.00	11.901
RS1	2014	128.00	11.612
RS1	2015	58.00	11.354
RS1	2016	111.00	11.083
RS2	2014	225.00	12.928
RS2	2015	95.00	12.936
RS2	2016	77.00	12.95
SE14	1994	0.33	7.71
SE14	1995	1.09	7.38
SE14	1996	3.12	9.02
SE14	1997	0.87	7.91
SE14	1998	0.15	5.94
SE14	1999	0.16	6.52
SE14	2000	0.17	6.78
SE14	2001	0.23	6.44
SE14	2002	0.25	7.02
SE14	2003	0.37	7.10
SE14	2004	0.15	5.22
SE14	2005	0.38	6.28
SE14	2006	0.68	5.30
SE14	2007	0.16	4.39
SE14	2008	0.21	3.72
SE14	2009	0.22	4.30
SE14	2010	4.24	3.61
SE14	2011	8.18	3.77
SE14	2012	20.97	3.28
SE14	2013	42.16	4.26
SE14	2014	7.93	4.14
SE14	2015	10.03	4.00
SE15	1994	0.55	3.16
SE15	1995	0.40	2.79
SE15	1996	1.32	3.25
SE15	1997	0.28	3.02
SE15	1998	0.60	2.49
SE15	1999	0.10	2.22
SE15	2000	0.19	1.83
SE15	2001	0.38	2.45
SE15	2002	0.41	2.33
SE15	2003	0.25	2.40
SE15	2004	0.27	1.74
SE15	2005	0.31	1.92
SE15	2006	0.50	1.56
SE15	2007	0.14	1.44
SE15	2008	0.19	1.06
SE15	2009	0.09	1.14
SE15	2010	0.15	1.11
SE15	2011	0.09	1.20
SE15	2012	0.09	0.98
SE15	2013	0.12	1.53
SE15	2014	0.11	1.49
SE15	2015	0.23	1.43
SE16	2000	0.14	1.41
SE16	2001	0.31	1.59

SE16	2002	0.22	1.89
SE16	2003	0.24	2.08
SE16	2004	0.27	1.77
SE16	2005	0.34	1.56
SE16	2007	0.07	0.99
SE16	2008	0.09	0.82
SE16	2009	0.10	0.99
SE16	2010	0.09	1.03
SE16	2011	0.06	0.87
SE16	2012	0.11	0.77
SE16	2013	0.15	0.90
SE16	2014	0.12	0.87
SE16	2015	0.11	0.83

Supplementary Table A11. Observed values (N=97) of soil solution [NH_4^+] at 6 sites, with corresponding modelled values.

Site	Observation year	Observed annual average [NH_4] (μeq L^{-1})	Modelled annual [NH_4] (μeq L^{-1})
FI01	2002	2.00	0.23
FI01	2004	3.00	0.07
FI01	2006	1.00	0.42
FI03	2002	10.00	0.20
FI03	2003	20.00	0.18
FI03	2004	10.00	0.06
FI03	2005	20.00	0.37
FI03	2006	4.00	0.23
NO01	1993	3.01	0.41
NO01	1994	2.41	0.39
NO01	1995	2.66	0.37
NO01	1996	1.53	0.37
NO01	1997	4.12	0.37
NO01	1998	2.62	0.37
NO01	1999	2.94	0.37
NO01	2000	3.81	0.37
NO01	2001	4.08	0.37
NO01	2002	5.51	0.37
NO01	2003	5.10	0.37
NO01	2004	4.59	0.37
NO01	2005	6.63	0.37
NO01	2006	5.00	0.37
NO01	2007	4.46	0.36
NO01	2008	2.02	0.36
NO01	2009	2.50	0.36
NO01	2010	4.08	0.35
NO01	2011	6.16	0.35
NO01	2012	2.32	0.35
NO01	2013	5.35	0.35
NO01	2014	3.30	0.35
RS1	2012	250.00	0.80
RS1	2013	243.00	0.80
RS1	2014	308.00	0.81
RS1	2015	133.00	0.82
RS1	2016	148.00	0.82
RS2	2014	190.00	0.66
RS2	2015	24.00	0.66
RS2	2016	45.00	0.66
SE14	1994	2.70	0.13
SE14	1995	2.34	0.16
SE14	1996	2.67	0.27
SE14	1997	1.36	0.15
SE14	1998	0.51	0.21
SE14	1999	1.64	0.14
SE14	2000	1.56	0.15
SE14	2001	1.45	0.17

SE14	2002	1.50	0.13
SE14	2003	2.62	0.17
SE14	2004	7.50	0.15
SE14	2005	2.26	0.15
SE14	2006	2.29	0.07
SE14	2007	1.61	0.11
SE14	2008	1.48	0.08
SE14	2009	1.97	0.11
SE14	2010	3.99	0.11
SE14	2011	5.19	0.07
SE14	2012	3.43	0.10
SE14	2013	5.55	0.10
SE14	2014	3.13	0.10
SE14	2015	2.64	0.10
SE15	1994	0.58	1.20
SE15	1995	0.56	1.10
SE15	1996	0.90	1.37
SE15	1997	0.25	1.21
SE15	1998	0.41	1.19
SE15	1999	1.22	1.05
SE15	2000	0.39	0.90
SE15	2001	0.36	1.16
SE15	2002	0.27	1.01
SE15	2003	0.89	1.04
SE15	2004	0.97	0.75
SE15	2005	0.97	0.77
SE15	2006	0.79	0.58
SE15	2007	0.50	0.62
SE15	2008	0.78	0.46
SE15	2009	0.55	0.51
SE15	2010	1.39	0.51
SE15	2011	0.73	0.50
SE15	2012	1.19	0.44
SE15	2013	1.15	0.64
SE15	2014	0.70	0.64
SE15	2015	1.75	0.63
SE16	2000	0.35	0.08
SE16	2001	0.39	0.09
SE16	2002	0.30	0.06
SE16	2003	0.49	0.08
SE16	2004	0.50	0.09
SE16	2005	0.33	0.07
SE16	2007	0.30	0.04
SE16	2008	0.14	0.04
SE16	2009	0.28	0.04
SE16	2010	0.18	0.04
SE16	2011	0.07	0.02
SE16	2012	0.56	0.04
SE16	2013	0.22	0.03
SE16	2014	0.38	0.03
SE16	2015	0.30	0.03

Supplementary Table A12. Observed values (N=144) of soil solution [SO_4^{2-}] at 9 sites, with corresponding modelled values.

Site	Observation year	Observed annual average [SO_4^{2-}] (μeq L^{-1})	Modelled annual [SO_4^{2-}] (μeq L^{-1})
AT01	1998	26.9	44.3
AT01	1999	41.8	36.8
AT01	2000	43.5	29.4
AT01	2001	52.2	28.2
AT01	2002	29.8	28.0
AT01	2003	39.8	28.0
AT01	2004	30.0	28.0
AT01	2005	30.2	28.0
AT01	2006	35.3	26.4
AT01	2007	26.0	24.4
AT01	2008	25.9	22.4
AT01	2009	25.4	20.5
AT01	2010	32.5	18.5
AT01	2011	32.0	18.1
AT01	2012	36.5	18.1
AT09	1998	640.0	147.9
AT09	1999	600.0	128.0
AT09	2000	610.0	108.1
AT09	2001	500.0	97.9
AT09	2002	600.0	91.9
AT09	2003	720.0	87.6
AT09	2004	630.0	84.0
AT09	2005	520.0	80.8
AT09	2006	430.0	76.8
AT09	2007	480.0	72.6
AT09	2008	510.0	68.3
AT09	2009	350.0	63.9
AT09	2010	310.0	59.4
AT09	2011	330.0	56.3
AT09	2012	370.0	53.6
AT16	1998	170.0	27.4
AT16	1999	130.0	25.5
AT16	2000	130.0	23.6
AT16	2001	100.0	22.5
AT16	2002	110.0	21.7
AT16	2003	110.0	20.9
AT16	2004	120.0	20.0
AT16	2005	120.0	19.2
AT16	2006	110.0	16.9
AT16	2007	100.0	14.3
AT16	2008	110.0	11.7
AT16	2009	70.0	9.1
AT16	2010	110.0	6.4
AT16	2011	80.0	5.7
BE001	1992	1270.0	1365.9
BE001	1993	910.0	1176.5

BE001	1994	550.0	859.9
BE001	1995	440.0	757.3
BE001	1996	880.0	1495.6
BE001	1997	990.0	2057.1
BE001	1998	1260.0	746.2
BE001	1999	520.0	861.1
BE001	2000	510.0	660.8
BE001	2001	370.0	518.8
BE001	2002	350.0	410.5
BE001	2003	340.0	807.8
BE001	2004	430.0	801.4
BE001	2005	610.0	877.0
BE001	2006	670.0	1001.1
BE001	2007	910.0	798.0
BE001	2008	500.0	589.4
BE001	2009	620.0	511.0
BE001	2010	470.0	301.2
BE001	2011	360.0	327.2
BE001	2012	310.0	291.3
BE001	2013	340.0	323.2
BE001	2014	360.0	292.1
BE001	2015	300.0	233.7
FI01	2002	280.0	107.6
FI01	2004	250.0	38.3
FI01	2006	230.0	57.9
FI03	2002	80.0	88.4
FI03	2003	60.0	48.2
FI03	2004	70.0	25.5
FI03	2005	100.0	61.3
FI03	2006	60.0	48.9
RS1	2011	1174.0	310.57
RS1	2012	1671.0	292.52
RS1	2013	807.0	271.94
RS1	2014	789.0	250.45
RS1	2015	991.0	228.61
RS1	2016	317.0	206.66
RS2	2014	821.0	323.28
RS2	2015	721.0	322.87
RS2	2016	173.0	322.67
SE14	1994	493.9	151.7
SE14	1995	308.7	130.6
SE14	1996	247.2	149.2
SE14	1997	257.8	134.3
SE14	1998	231.6	95.7
SE14	1999	209.7	87.7
SE14	2000	223.4	84.6
SE14	2001	193.4	78.5
SE14	2002	162.0	81.8
SE14	2003	155.8	84.1
SE14	2004	211.2	62.4
SE14	2005	175.6	64.7
SE14	2006	154.0	56.2
SE14	2007	106.9	46.0
SE14	2008	117.6	36.7
SE14	2009	110.7	38.3

SE14	2010	99.1	32.7
SE14	2011	84.1	31.0
SE14	2012	66.0	26.0
SE14	2013	103.4	30.7
SE14	2014	159.0	31.7
SE14	2015	165.3	31.1
SE15	1994	230.0	130.7
SE15	1995	191.8	105.5
SE15	1996	193.9	112.4
SE15	1997	186.1	102.1
SE15	1998	171.2	83.1
SE15	1999	160.7	66.6
SE15	2000	150.7	49.0
SE15	2001	123.1	58.1
SE15	2002	129.2	57.4
SE15	2003	133.5	58.1
SE15	2004	119.1	42.6
SE15	2005	106.8	40.0
SE15	2006	106.3	31.9
SE15	2007	98.1	29.9
SE15	2008	97.1	22.8
SE15	2009	93.6	21.8
SE15	2010	88.9	20.7
SE15	2011	92.8	21.0
SE15	2012	90.1	17.0
SE15	2013	99.4	23.5
SE15	2014	84.6	25.5
SE15	2015	96.7	25.5
SE16	2000	41.1	24.0
SE16	2001	31.9	22.9
SE16	2002	30.7	27.0
SE16	2003	31.6	30.6
SE16	2004	30.0	28.1
SE16	2005	25.6	24.1
SE16	2007	26.8	15.4
SE16	2008	21.9	12.9
SE16	2009	22.0	13.5
SE16	2010	19.2	14.0
SE16	2011	16.7	11.9
SE16	2012	15.9	9.9
SE16	2013	16.9	10.4
SE16	2014	23.2	10.3
SE16	2015	25.4	10.0

Table A13. Observed values (N=100) of soil solution [Bc^{2+}] at 6 sites, with corresponding modelled values. Bc is the sum of Ca, Mg and K, where two K^+ ions are treated as one divalent ion.

Site	Observation year	Observed annual average Bc (μeq L^{-1})	Modelled annual Bc (μeq L^{-1})
BE001	1992	720.0	524.7
BE001	1993	730.0	450.5
BE001	1994	470.0	340.6
BE001	1995	530.0	265.4
BE001	1996	590.0	453.2
BE001	1997	530.0	563.2
BE001	1998	520.0	230.4
BE001	1999	320.0	257.3
BE001	2000	330.0	298.6
BE001	2001	220.0	199.4
BE001	2002	200.0	186.6
BE001	2003	150.0	332.6
BE001	2004	160.0	384.9
BE001	2005	190.0	415.9
BE001	2006	210.0	451.6
BE001	2007	260.0	353.0
BE001	2008	200.0	276.0
BE001	2009	200.0	228.8
BE001	2010	130.0	142.5
BE001	2011	80.0	156.4
BE001	2012	140.0	133.3
BE001	2013	130.0	168.1
BE001	2014	140.0	153.8
BE001	2015	100.0	130.4
FI01	2002	180.0	77.3
FI01	2004	160.0	58.0
FI01	2006	160.0	59.4
FI03	2002	80.0	3.9
FI03	2003	170.0	1.7
FI03	2004	70.0	0.9
FI03	2005	90.0	2.4
FI03	2006	130.0	1.8
RS1	2011	2001.0	337.0
RS1	2012	566.0	320.7
RS1	2013	423.0	301.3
RS1	2014	239.0	280.8
RS1	2015	26.0	260.4
RS1	2016	223.0	239.6
RS2	2014	875.0	449.1
RS2	2015	68.0	448.8
RS2	2016	368.0	448.7
SE14	1994	323.0	174.3
SE14	1995	173.0	159.8
SE14	1996	190.0	175.0
SE14	1997	193.0	164.0
SE14	1998	145.0	134.9
SE14	1999	107.0	129.8

SE14	2000	117.0	127.9
SE14	2001	95.0	130.3
SE14	2002	105.0	133.6
SE14	2003	100.0	136.1
SE14	2004	104.0	118.8
SE14	2005	97.0	122.2
SE14	2006	65.0	115.9
SE14	2007	74.0	108.2
SE14	2008	70.0	101.4
SE14	2009	65.0	103.9
SE14	2010	96.0	99.3
SE14	2011	156.0	103.4
SE14	2012	163.0	99.0
SE14	2013	290.0	104.3
SE14	2014	203.0	105.7
SE14	2015	242.0	105.7
SE15	1994	75.0	37.7
SE15	1995	50.0	32.7
SE15	1996	59.0	36.6
SE15	1997	48.0	34.8
SE15	1998	41.0	29.4
SE15	1999	41.0	24.4
SE15	2000	34.0	18.3
SE15	2001	32.0	42.4
SE15	2002	32.0	43.3
SE15	2003	33.0	45.9
SE15	2004	28.0	34.4
SE15	2005	28.0	34.9
SE15	2006	26.0	29.0
SE15	2007	30.0	29.1
SE15	2008	27.0	23.1
SE15	2009	32.0	23.3
SE15	2010	25.0	22.9
SE15	2011	33.0	24.3
SE15	2012	30.0	19.6
SE15	2013	30.0	30.2
SE15	2014	28.0	34.5
SE15	2015	33.0	36.1
SE16	2000	37.0	41.2
SE16	2001	26.0	40.0
SE16	2002	23.0	44.6
SE16	2003	30.0	50.7
SE16	2004	31.0	53.3
SE16	2005	32.0	54.4
SE16	2007	30.0	51.4
SE16	2008	30.0	50.5
SE16	2009	37.0	53.7
SE16	2010	26.0	56.7
SE16	2011	35.0	54.8
SE16	2012	51.0	50.9
SE16	2013	24.0	52.1
SE16	2014	29.0	52.8
SE16	2015	21.0	53.3