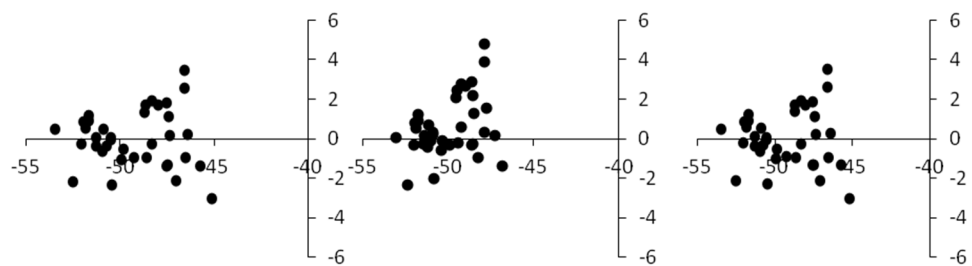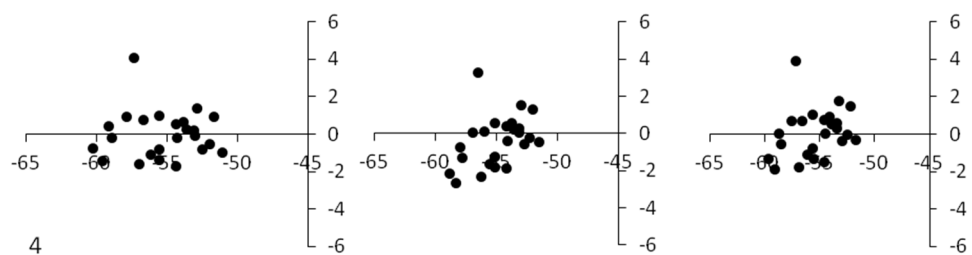Table S1: the 9 selected catchment characteristics for the 9 rivers considered in this study.
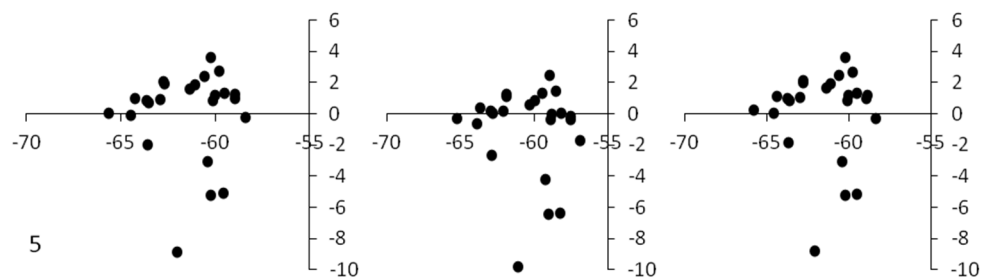
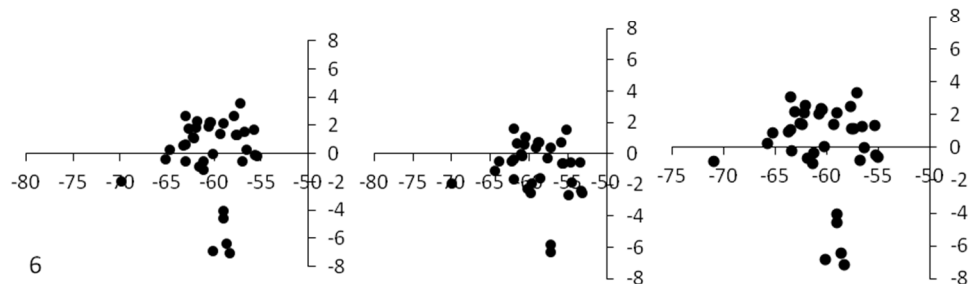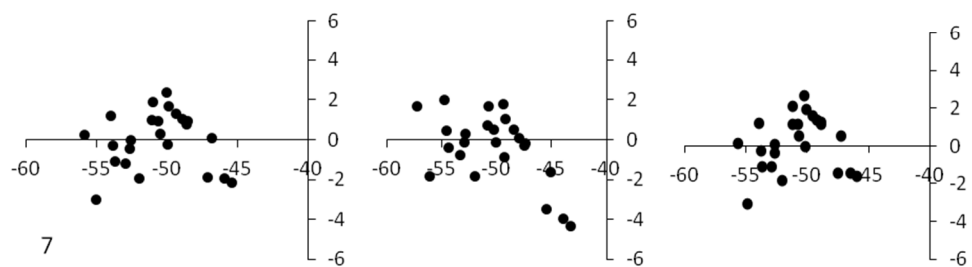| River (Code)	Catchment Characteristics								
	H_{min} (m a.s.l.)	A (km²)	H_{max} (m a.s.l.)	H_{mean} (m a.s.l.)	q (L s⁻¹ km⁻²)	q95 (L s⁻¹ km⁻²)	P (mm)	F (km)	Fyw(%)
Trebbia (1)	257	655	1735	938	19.4	1.6	1304	65.5	9.5
Nure (2)	421	208	1753	944	15.7	1.3	1094	20.9	12.0
Taro (3)	135	1246	1799	712	8.4	1.0	990	71	16.6
Enza (4)	231	430	2016	802	22.4	0.7	924	28	11.1
Secchia (5)	47	1303	2121	694	36.3	1.0	999	85.2	9.3
Panaro (6)	212	584	2165	939	7.4	1.7	1017	40.9	11.7
Reno (7)	60	1056	1945	639	10.8	1.1	1063	81.8	11.9
Lamone (8)	135	193	1158	593	2.2	0.5	1257	28.5	22.9
Savio (9)	43	586	1361	526	9.8	0.0	1167	77.4	18.7
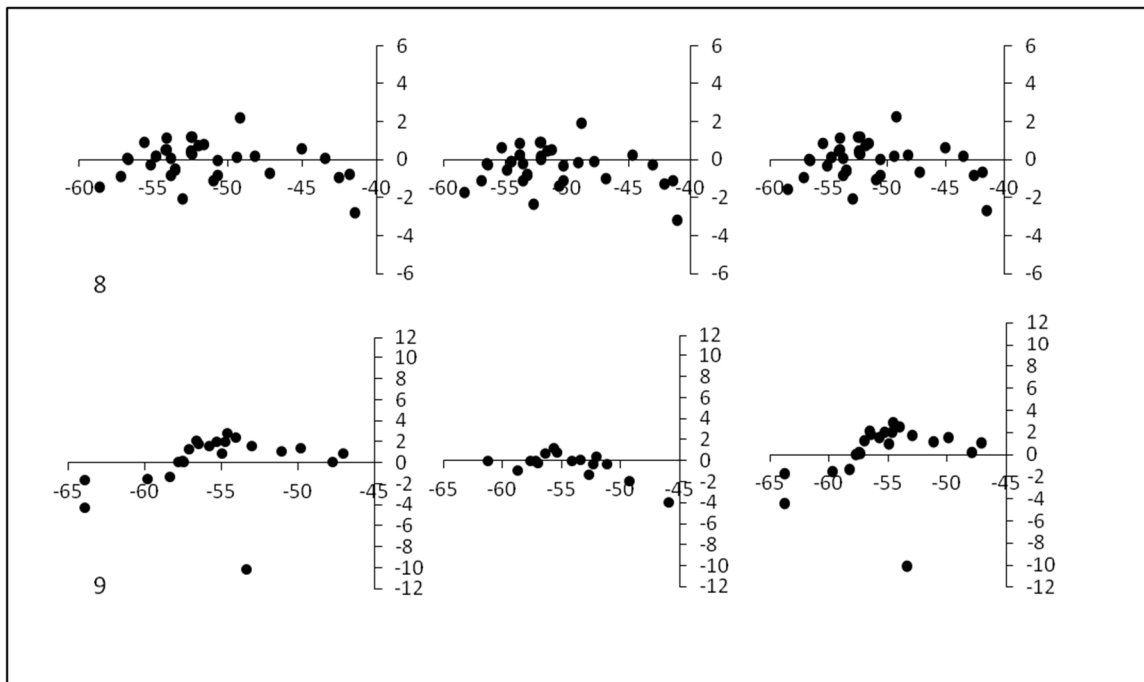
Figure S1: plots of standardized residuals of regression approaches OLS (on the left), R (in the centre) and PW (on the right) for surface water affected by non stationary processes (rivers "1,4,5,6,7").

Figure S2: autocorrelation functions of standardized residuals for surface water affected by serial correlations (in form of bars at a lag of 1; rivers "1,4,6,7") along with the corresponding 95 percent confidence intervals (see [25] for deta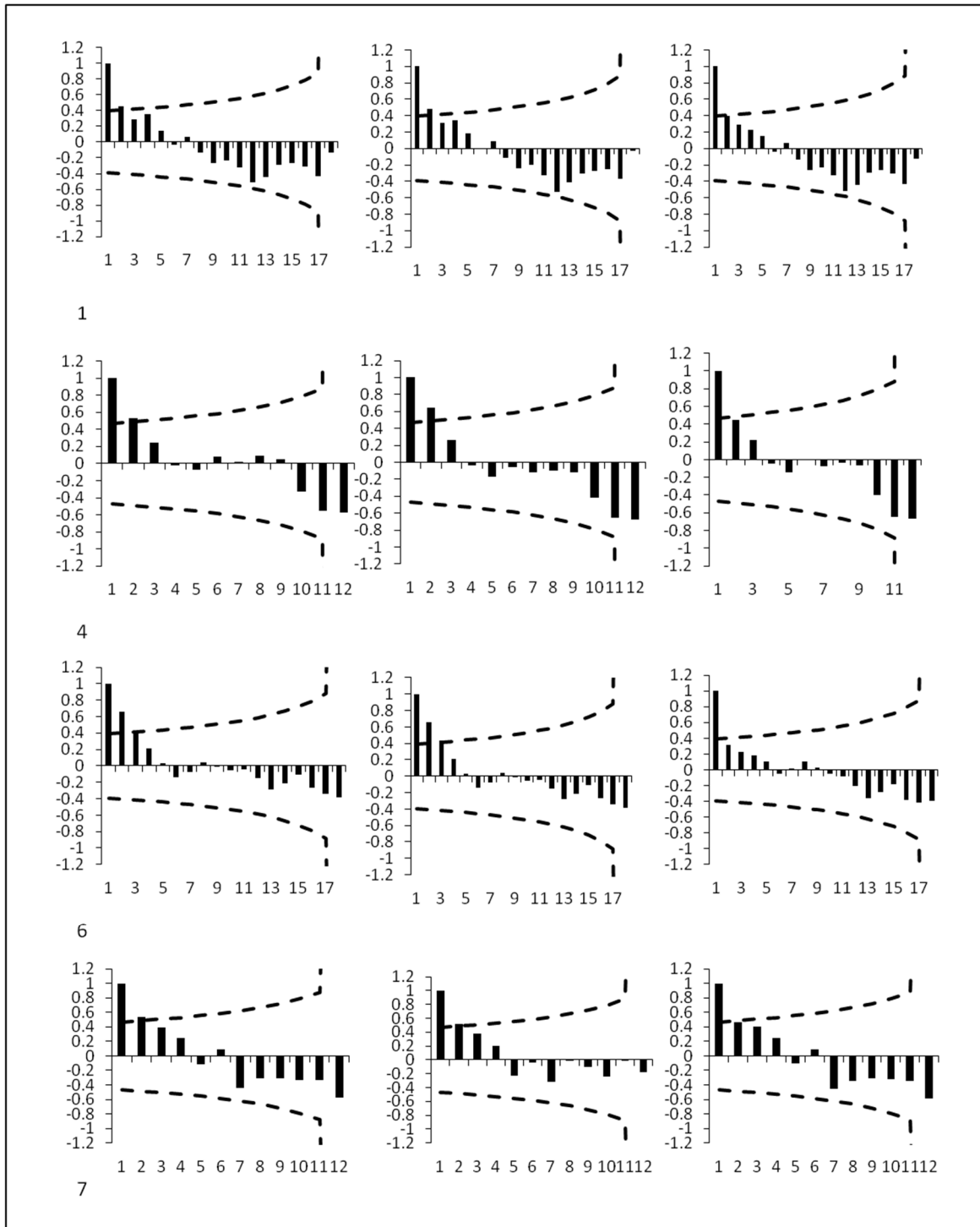ils). Standardized residuals of regression approaches were reported from OLS (on the left), R (in the centre) and PW (on the right).

Table S2: Slopes from $\delta^{18}O$–δ^2H regression. n.a. not available

Water type	Code	Name	OLS	RMA	MA	E	PW	W	B
Surficial water	1	Trebbia	5.3	6.3	7.5	3.9	5.3	6.4	6.4
	2	Nure	6.1	6.8	7.7	6.0	6.1	7.0	7.1
	3	Taro	6.5	6.8	7.0	6.2	6.9	6.5	5.8
	4	Enza	5.4	6.0	6.6	4.3	4.7	6.0	6.6
	5	Secchia	4.3	7.5	13.0	4.9	4.4	2.3	1.9
	6	Panaro	5.6	7.4	9.7	6.5	6.1	5.1	4.9
	7	Reno	5.6	6.3	7.1	7.6	5.3	6.0	5.7
	8	Lamone	5.6	5.7	5.9	5.6	5.5	5.9	6.3
	9	Savio	5.0	5.5	6.1	8.7	4.9	4.6	3.5
			OLS	RMA	MA	E	PW	W	B
Precipitations	a	Parma	7.6	7.7	7.8	7.9	7.6	7.2	7.2
	b	Lodesana	7.8	7.8	7.9	8.3	7.9	7.9	8.4
	c	Langhirano	7.8	7.8	7.9	8.1	7.7	7.9	8.4
	d	Berceto	6.7	6.7	6.8	8.1	6.7	7.5	7.8
			OLS	RMA	MA	E	PW	W	B
Groundwater from wells	A	Trebbia	7.4	8.0	8.7	6.3	7.4	n.a.	n.a.
	B	Taro	9.2	10.5	12.0	5.9	8.9	n.a.	n.a.
	C	Enza	10.2	10.8	11.5	9.2	10.5	n.a.	n.a.
	D	Secchia	7.9	8.0	8.0	7.9	7.9	n.a.	n.a.
			OLS	RMA	MA	E	PW	W	B
Groundwater from springs	α	Pietra di Bismantova	7.4	7.7	8.1	9.6	7.3	n.a.	n.a.
	β	Montacagno	5.3	6.4	7.6	7	5.3	n.a.	n.a.

Table S3: Intercepts from $\delta^{18}O$–δ^2H regression. n.a. not available

Water type	Code	Name	OLS	RMA	MA	E	PW	W	B
Surficial water	1	Trebbia	-9.0	-1.1	8.0	-19.7	-9.1	-0.1	0.2
	2	Nure	-5.3	1.3	8.3	-5.7	-4.9	3.0	3.6
	3	Taro	0.5	2.3	4.0	-1.7	3.0	0.1	-5.6
	4	Enza	-9.9	-5.0	0.2	-18.8	-15.9	-4.3	0.5
	5	Secchia	-22.8	6.3	55.9	-15.8	-21.6	-42.3	-46.0
	6	Panaro	-10.6	5.6	26.4	-0.9	-5.5	-15.0	-17.0
	7	Reno	-6.7	-1.4	4.3	8.8	-9.8	-3.5	-5.6
	8	Lamone	-6.8	-5.7	-4.7	-6.3	-7.3	-4.3	-1.1
	9	Savio	-13.7	-9.3	-4.7	19.1	-14.4	-17.1	-27.2
Precipitations			OLS	RMA	MA	E	PW	W	B
	a	Parma	6.9	7.7	8.5	11.6	6.9	4.0	3.3
	b	Lodesana	7.8	8.3	8.8	10.6	7.9	9.1	13.1
	c	Langhirano	7.6	8.1	8.5	9.5	7.0	9.7	13.1
	d	Berceto	-3.0	-2.5	-2.1	11.5	-4.7	-1.0	2.5
Groundwater from wells			OLS	RMA	MA	E	PW	W	B
	A	Trebbia	5.6	11.1	16.9	-4.1	5.7	n.a.	n.a.
	B	Taro	21.3	32.1	44.3	-6.0	18.8	n.a.	n.a.
	C	Enza	29.8	35.4	41.2	22.4	32.4	n.a.	n.a.
	D	Secchia	9.5	10.3	11.1	8.8	9.7	n.a.	n.a.
			OLS	RMA	MA	E	PW	W	B
Groundwater from springs	α	Pietra di Bismantova	4.7	8.3	12.0	26.4	4.0	n.a.	n.a.
	β	Montacagno	-15.6	-5.5	6.1	0.0	0.4	n.a.	n.a.

Table S4: Standard deviations of the estimates from $\delta^{18}O$–$\delta^{2}H$ regression. n.a. not available

Water type	Code	Name	OLS	RMA	MA	E	PW	W	B
Precipitations	a	Parma	0.19	0.19	0.20	0.48	0.20	0.21	0.18
	b	Lodesana	0.22	0.22	0.23	0.71	0.17	0.21	0.21
	c	Langhirano	0.22	0.22	0.23	0.82	0.23	0.20	0.19
	d	Berceto	0.23	0.23	0.24	2.38	0.23	0.25	0.27
Surficial water	1	Trebbia	0.59	0.59	0.84	1.86	0.68	0.54	0.55
	2	Nure	0.67	0.67	0.84	1.01	0.77	0.52	0.53
	3	Taro	0.30	0.30	0.32	0.78	0.36	0.48	0.45
	4	Enza	0.55	0.55	0.67	1.66	0.59	0.47	0.47
	5	Secchia	1.32	1.32	3.98	1.20	1.54	1.45	1.52
	6	Panaro	0.83	0.83	1.44	1.27	0.82	0.27	0.29
	7	Reno	0.61	0.61	0.76	2.81	0.70	0.19	0.20
	8	Lamone	0.21	0.21	0.22	0.79	0.24	0.20	0.20
	9	Savio	0.51	0.51	0.62	1.56	0.47	2.12	2.05
Groundwater from wells	A	Trebbia	0.39	0.39	0.46	1.11	0.38	n.a.	n.a.
	B	Taro	1.14	1.14	1.48	2.69	0.98	n.a.	n.a.
	C	Enza	0.81	0.81	0.91	1.64	0.72	n.a.	n.a.
	D	Secchia	0.21	0.21	0.21	0.93	0.25	n.a.	n.a.
Groundwater from springs	α	Pietra di Bismantova	0.43	0.43	0.47	1.43	0.43	n.a.	n.a.
	β	Montecagno	0.81	0.81	1.16	0.06	0.81	n.a.	n.a.

Table S5: Coefficients of determination R^2 from $\delta^{18}O$–δ^2H regression. n.a. not available

| Water type	Code	Name	OLS	RMA	MA	E	PW	W	B
Precipitations	a	Parma	0.98	0.98	0.98	0.98	0.98	0.95	0.97
	b	Lodesana	0.99	0.99	0.99	0.99	0.99	0.97	0.96
	c	Langhirano	0.99	0.99	0.99	0.99	0.99	0.98	0.98
	d	Berceto	0.99	0.99	0.99	0.99	0.99	0.94	0.93
Surficial water	1	Trebbia	0.70	0.70	0.70	0.70	0.70	0.83	0.82
	2	Nure	0.79	0.79	0.79	0.79	0.79	0.86	0.85
	3	Taro	0.93	0.93	0.93	0.93	0.93	0.88	0.89
	4	Enza	0.81	0.81	0.81	0.81	0.81	0.88	0.89
	5	Secchia	0.32	0.32	0.32	0.32	0.32	0.17	0.15
	6	Panaro	0.57	0.57	0.57	0.57	0.57	0.87	0.85
	7	Reno	0.79	0.79	0.79	0.79	0.79	0.94	0.94
	8	Lamone	0.95	0.95	0.95	0.95	0.95	0.92	0.93
	9	Savio	0.81	0.81	0.81	0.81	0.81	0.18	0.20
Groundwater from wells	A	Trebbia	0.85	0.85	0.85	0.85	0.85	n.a.	n.a.
	B	Taro	0.77	0.77	0.77	0.77	0.77	n.a.	n.a.
	C	Enza	0.88	0.88	0.88	0.88	0.88	n.a.	n.a.
	D	Secchia	0.98	0.98	0.98	0.98	0.98	n.a.	n.a.
Groundwater from springs	α	Pietra di Bismantova	0.95	0.95	0.95	0.95	0.95	n.a.	n.a.
	β	Montecagno	0.69	0.69	0.69	0.69	0.69	n.a.	n.a.
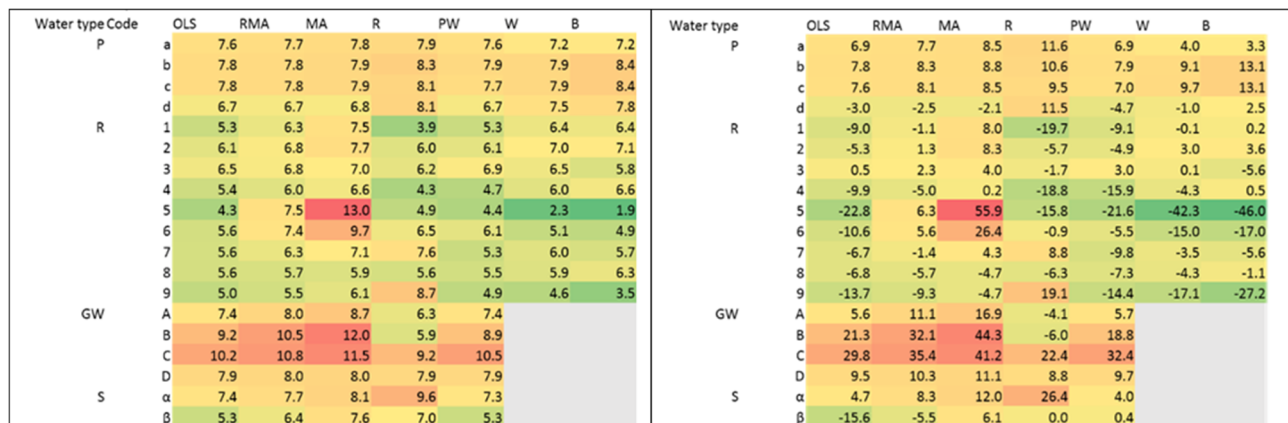
Figure S3: Heatmaps reporting slopes values (on the left) and intercepts values (on the right) as computed by the several regression approaches (OLS, RMA, MA, R, PW, W, B) for the different monitoring points belonging to 4 water types (P: precipitation water; R: river water; GW: groundwater from wells; S: groundwater from springs).
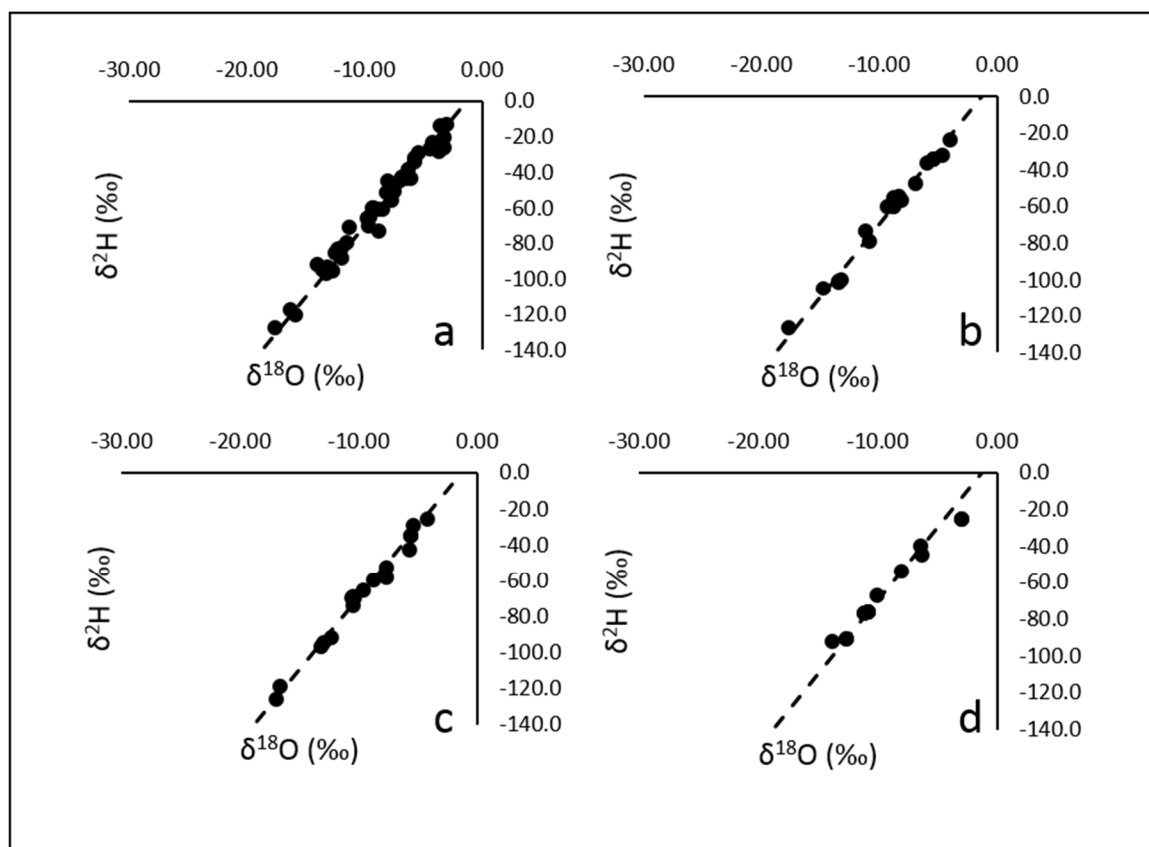
Figure S4: δ¹⁸O–δ²H pairs from rain gauges Parma (a), Lodesana (b), Langhirano (c) and Berceto (d) along with Global Meteoric Water Line (GMWL; dashed black line).
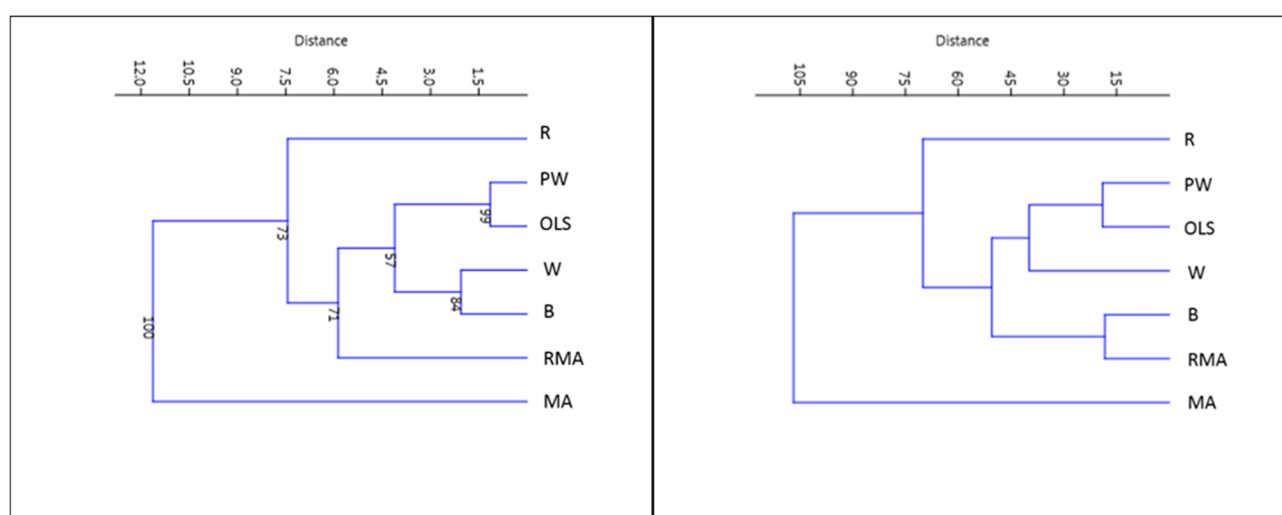

Figure S5: Dendrogram for slope (on the left) and intercepts (on the right) series.
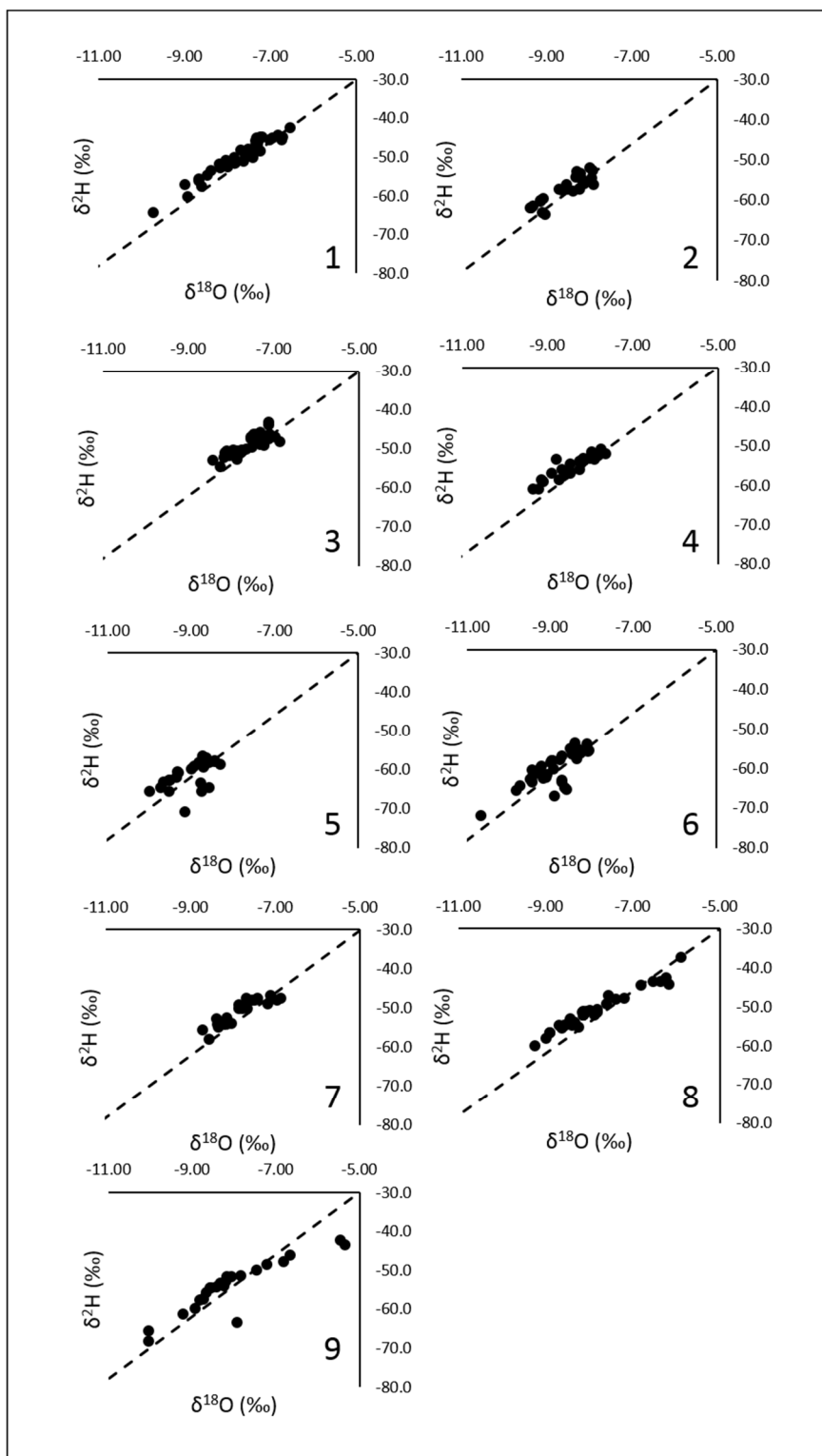
Figure S6: δ¹⁸O–δ²H pairs from rivers (surface water) 1 (Trebbia), 2 (Nure), 3 (Taro), 4 (Enza), 5 (Secchia), 6 (Panaro), 7 (Reno), 8 (Lamone), 9 (Savio) along with Global Meteoric Water Line (GMWL; dashed black line).
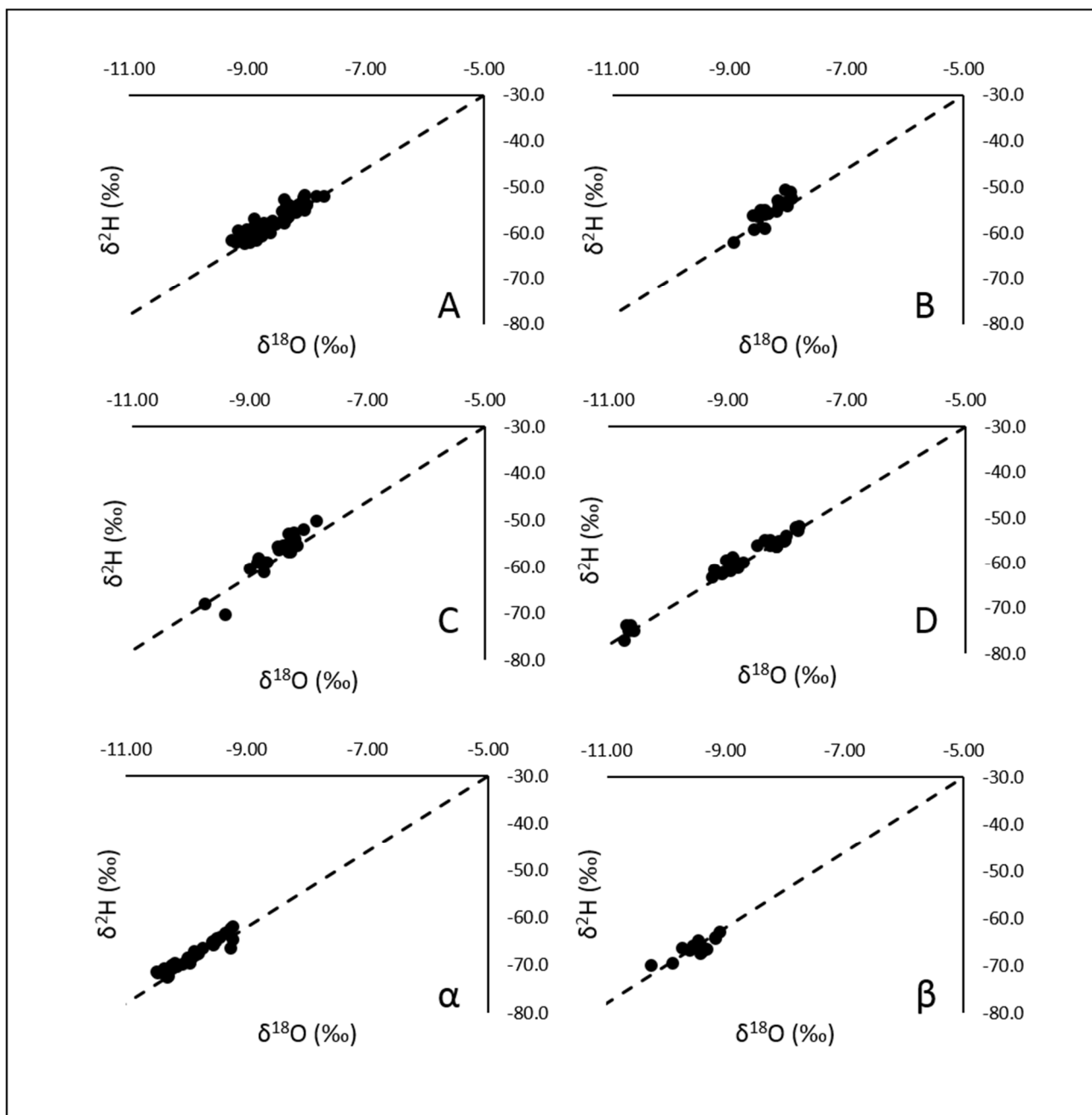
Figure S7: δ^{18}O–δ^{2}H pairs from groundwater from wells A (Trebbia alluvial fan), B (Taro alluvial fan), C (Enza alluvial fan), D (Secchia alluvial fan) and from springs α (Pietra di Bismantova) and β (Montecagno).along with Global Meteoric Water Line (GMWL; dashed black line).