Supplementary Information for

Precipitation in the mountains of Central Asia: isotopic composition and source regions

Saidaliyeva Z.[1], Shahgedanova M.[1], Yapiyev V.[1,2], Wade A.J.[1], Akbarov F.[3], Esenaman uulu M.[4], Kalashnikova O.[4], Kapitsa V.[5], Kasatkin N.[5], Rakhimov I.[6], Satylkanov R.[7], Sayakbaev D.[7], Semakova E.[8], Severskiy I.[5], Petrov M.[3], Umirzakov G.[9], and Usubaliev R.[4]

[1]Department of Geography and Environmental Science, University of Reading, Reading, RG66AB, UK;
[2]School of Mining and Geosciences, Nazarbayev University, Astana, 010000, Kazakhstan
[3]Institute of Geology and Geophysics, Tashkent, 100164, Uzbekistan;
[4]Central-Asian Institute for Applied Geosciences, Bishkek, 720027, Kyrgyzstan;
[5]Central Asian Regional Glaciological Centre Under the Auspices of UNESCO, Almaty, 050010, Kazakhstan;
[6]Institute of Water Problems, Hydropower and Environment, Dushanbe, 734025, Tajikistan;
[7]Tien-Shan High Mountain Scientific Centre, Bishkek, 720033, Kyrgyzstan;
[8]Ulugh Beg Astronomical Institute of the Uzbekistan Academy of Science Tashkent, 100052, Uzbekistan;
[9]National University of Uzbekistan, Tashkent, 100174, Uzbekistan;

Correspondence to: Zarina Saidaliyeva (z.saidaliyeva@pgr.reading.ac.uk)

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Table S1: Descriptive statistics of stable isotope ratios and D-excess. N is number of samples; SD is standard deviation.

Catchment	Ulken Almaty					Chon Kyzyl Suu					Ala Archa					Chirchik				
Temporal Resolusion/Type	**N**	**Mean**	**SD**	**Min**	**Max**	**N**	**Mean**	**SD**	**Min**	**Max**	**N**	**Mean**	**SD**	**Min**	**Max**	**N**	**Mean**	**SD**	**Min**	**Max**
Oxygen, ‰																				
January	8	-22.5	5.9	-33.6	-12.1	7	-11.7	4.6	-17.3	-4.9	7	-13.1	5.4	-20.2	-5.8	24	-16.4	6.6	-32.4	-5.5
February	21	-15.7	6.7	-25.5	-3.3	9	-16.4	6.6	-23.8	-1.7	16	-12.6	4.8	-22.1	-6.6	53	-10.1	5.1	-23.8	-0.1
March	25	-12.7	4.2	-20.7	-7.2	9	-11.1	1.7	-13.8	-8.8	16	-11.0	5.2	-21.5	-1.7	44	-7.2	4.6	-16.0	3.8
April	20	-13.8	5.4	-24.6	-4.2	18	-12.0	5.1	-20.4	-3.4	9	-9.5	5.7	-14.9	1.9	35	-7.4	5.5	-17.8	3.3
May	37	-9.0	3.4	-13.2	-0.1	33	-9.5	3.5	-15.8	-2.5	12	-5.2	2.0	-9.4	-2.1	33	-2.7	3.6	-9.0	4.3
June	47	-5.0	3.6	-11.0	1.4	30	-5.4	4.1	-12.8	6.0	5	-5.0	2.3	-8.0	-2.4	17	0.2	4.2	-13.0	4.3
July	45	-4.1	4.0	-12.3	6.1	31	-3.1	2.7	-7.7	5.5	8	-2.0	3.1	-7.2	2.4	15	-1.6	2.9	-5.9	2.8
August	49	-5.6	4.4	-16.4	1.1	24	-5.3	3.1	-11.6	0.7	15	-0.4	5.2	-10.6	8.6	11	-4.0	4.2	-12.9	-0.2
September	34	-8.0	5.1	-23.6	3.8	14	-6.3	3.9	-12.1	2.8	6	-3.4	5.3	-8.8	3.2	4	-4.9	3.6	-10.0	-1.8
October	30	-12.7	4.1	-19.7	-6.5	5	-8.4	4.9	-13.8	-2.3	7	-12.1	4.3	-19.7	-7.6	4	-5.5	3.5	-10.5	-2.9
November	14	-16.4	6.0	-27.4	-5.8	2	-19.2	1.6	-20.4	-18.1	7	-12.6	4.8	-21.1	-6.1	14	-18.8	6.6	-30.8	-11.7
December	8	-19.3	6.3	-28.5	-12.5	1	-15.4	-	-15.4	-15.4	7	-15.0	4.9	-21.7	-9.3	18	-14.1	5.0	-20.9	-6.0
DJF	37	-17.9	6.9	-33.6	-3.3	17	-14.4	5.9	-23.8	-1.7	30	-13.3	4.9	-22.1	-5.8	95	-12.5	6.1	-32.4	-0.1
MAM	82	-11.3	4.7	-24.6	-0.1	60	-10.5	4.0	-20.4	-2.5	37	-8.7	5.1	-21.5	1.9	112	-6.0	5.0	-17.8	4.3
JJA	141	-4.9	4.1	-16.4	6.1	85	-4.6	3.5	-12.8	6.0	28	-1.7	4.5	-10.6	8.6	43	-1.5	4.0	-13.0	4.3
SON	78	-11.3	5.8	-27.4	3.8	21	-8.0	5.4	-20.4	2.8	20	-9.7	6.2	-21.1	3.2	22	-13.8	8.7	-30.8	-1.8
Annual	338	-9.4	6.6	-33.6	6.1	183	-7.8	5.3	-23.8	6.0	115	-8.4	6.6	-22.1	8.6	272	-8.2	7.1	-32.4	4.3
Mixed	45	-8.5	3.6	-16.4	-0.1	14	-11.5	3.3	-15.5	-1.7	17	-10.5	1.6	-13.8	-8.0	44	-10.1	3.9	-20.0	-2.8
Rain	173	-5.4	4.1	-14.8	6.1	137	-5.7	3.8	-15.8	6.0	66	-4.2	4.6	-12.9	8.6	152	-4.0	4.7	-16.5	4.3
Snow	120	-15.4	5.7	-33.6	-3.3	32	-15.0	4.4	-23.8	-4.9	32	-15.7	4.2	-22.1	-5.8	76	-15.4	6.0	-32.4	-4.7
Hydrogen, ‰																				
January	8	-168.9	49.7	-258.8	-78.8	7	-87.3	29.5	-138.6	-58.2	7	-86.5	46.9	-140.9	-30.8	24	-123.2	55.5	-247.9	-43.5
February	21	-119.1	51.1	-203.7	-47.0	9	-125.3	45.4	-186.5	-39.8	16	-82.9	40.5	-166.4	-32.8	53	-68.5	44.7	-188.0	11.8
March	25	-87.3	32.7	-148.5	-48.9	9	-83.0	15.1	-101.3	-57.8	16	-72.0	40.5	-159.9	-13.1	44	-42.8	35.2	-117.9	24.1
April	20	-97.6	45.7	-187.6	-10.0	18	-87.9	40.8	-156.9	-3.9	9	-61.1	43.8	-103.8	27.3	35	-47.4	44.3	-128.6	29.7
May	37	-56.3	26.5	-92.7	3.4	33	-61.1	30.8	-115.1	6.8	12	-28.3	17.7	-57.0	-1.8	33	-15.5	27.5	-63.5	29.4
June	47	-29.6	22.8	-70.9	9.4	30	-32.5	26.3	-85.3	17.1	5	-34.7	14.5	-48.0	-14.0	17	-0.1	28.1	-89.2	36.5
July	45	-23.9	24.6	-76.3	38.2	31	-10.2	17.6	-45.8	19.6	8	-16.4	27.7	-62.8	25.8	15	-16.6	20.5	-50.9	21.3
August	49	-31.8	30.6	-112.3	6.9	24	-22.8	23.2	-71.3	18.9	15	2.7	28.9	-63.2	45.2	11	-18.3	29.3	-82.0	10.2

September	34	-48.1	37.9	-176.8	26.6	14	-27.9	26.5	-68.7	30.0	6	-12.6	32.7	-53.2	24.9	4	-32.0	29.8	-68.6	-4.4
October	30	-87.3	30.6	-142.3	-47.9	5	-55.2	29.6	-93.3	-24.5	7	-73.4	42.0	-141.8	-25.4	4	-23.3	28.5	-64.0	-0.5
November	14	-114.9	44.9	-187.8	-43.4	2	-140.0	6.5	-144.7	-135.4	7	-76.0	40.1	-151.9	-42.3	14	-134.9	55.3	-237.1	-78.3
December	8	-140.3	53.9	-214.8	-86.9	1	-102.6	-	-102.6	-102.6	7	-90.3	40.5	-153.9	-44.8	18	-97.3	40.3	-151.2	-20.5
DJF	37	-134.5	53.9	-258.8	-47.0	17	-108.3	41.4	-186.5	-39.8	30	-85.5	40.6	-166.4	-30.8	95	-87.8	52	-247.9	11.8
MAM	82	-75.8	38.1	-187.6	3.4	60	-72.4	34.4	-156.9	6.8	37	-55.2	39.8	-159.9	27.4	112	-36.2	38.5	-128.6	29.7
JJA	141	-28.6	26.3	-112.3	38.2	85	-21.6	24.2	-85.3	19.6	28	-9.4	29.6	-63.2	45.2	43	-10.5	26.8	-89.22	36.5
SON	78	-75.2	44.5	-187.8	26.6	21	-45.1	42.1	-144.7	30.0	20	-56.1	46.9	-151.9	24.9	22	-95.9	70.2	-237.1	-0.5
Annual	338	-62.4	50.3	-258.8	38.2	183	-49.0	43.2	-186.5	30.0	115	-52.1	47.3	-166.4	45.2	272	-55	54.9	-247.9	36.5
Mixed	45	-52.6	26.4	-112.3	5.5	14	-88.0	17.8	-114.1	-39.8	17	-61.4	13.5	-94.4	-44.8	44	-62.8	34.5	-152.8	-0.97
Rain	173	-31.4	26.6	-104.1	38.2	137	-30.6	28.4	-115.1	30.0	66	-22.8	29.9	-83.0	45.2	152	-24.3	34.4	-119.9	36.5
Snow	120	-110.8	45.7	-258.8	-10.5	32	-110.6	34.0	-186.5	-58.2	32	-107.5	34.9	-166.4	-30.8	76	-112	50.7	-247.9	-15.3
D-excess, ‰																				
January	8	10.8	7.9	-4.9	18.1	7	6.5	16.4	-19.3	22.4	7	18.2	7.1	9.5	29.0	24	8.1	13.7	-25.4	35.3
February	21	6.4	10.9	-22.2	17.1	9	5.6	13.3	-26.1	15.7	16	18.0	4.8	9.0	25.9	53	12.6	10.3	-18.2	34.1
March	25	14.0	6.7	-3.7	23.1	9	6.2	5.4	-3.2	12.4	16	15.8	7.1	-1.6	25.3	44	14.9	8.7	-6.7	33.2
April	20	12.5	7.8	-11.0	26.5	18	7.9	9.2	-19.1	23.3	9	14.9	3.7	7.5	20.0	35	11.8	6.0	-1.8	24.5
May	37	15.8	6.7	-8.3	24.4	33	14.5	4.8	4.5	27.1	12	13.5	5.5	6.8	23.7	33	6.5	9.3	-12.2	21.2
June	47	10.5	9.9	-14.5	23.0	30	10.7	9.9	-31.0	21.1	5	5.1	7.6	-2.2	17.4	17	-1.7	9.2	-15.7	14.9
July	45	8.8	11.5	-26.5	23.1	31	14.9	9.7	-26.3	27.1	8	-0.1	8.7	-14.9	11.8	15	-3.5	9.1	-25.2	10.0
August	49	13.1	7.5	-5.1	24.1	24	19.8	6.5	-0.2	29.1	15	6.2	17.6	-23.8	46.4	11	13.4	8.4	-4.1	23.8
September	34	15.8	8.1	-4.0	29.1	14	22.4	5.4	7.5	28.3	6	14.3	14.4	-0.9	40.4	4	6.8	10.3	-5.5	18.4
October	30	14.1	8.0	-5.0	29.3	5	11.6	11.5	-5.9	22.4	7	23.5	11.2	13.1	41.1	4	20.6	1.5	19.8	22.8
November	14	16.5	9.9	3.1	31.1	2	13.8	6.2	9.4	18.2	7	24.8	17.4	6.2	54.2	14	15.5	5.4	8.7	26.3
December	8	14.2	6.1	6.2	25.9	1	20.9	*	20.9	20.9	7	29.5	13.6	11.1	45.7	18	15.8	5.5	6.4	30.1
DJF	37	9.0	9.8	-22.2	25.9	17	6.9	14.3	-26.1	22.4	30	20.7	9.2	9.0	45.7	95	12.1	10.8	-25.4	35.3
MAM	82	14.5	7.0	-11.0	26.5	60	11.3	7.4	-19.1	27.1	37	14.8	5.9	-1.6	25.3	112	11.4	8.8	-12.2	33.2
JJA	141	10.9	9.8	-26.5	24.1	85	14.8	9.6	-31.0	29.1	28	4.2	14.0	-23.8	46.4	43	1.5	11.2	-25.2	23.8
SON	78	15.2	8.3	-5.0	31.1	21	19.0	8.5	-5.9	28.3	20	21.2	14.5	-0.9	54.2	22	14.9	7.2	-5.5	26.3
Annual	338	12.5	9.1	-26.5	31.1	183	13.4	9.8	-31.0	29.1	115	14.9	12.6	-23.8	54.2	272	10.4	10.6	-25.4	35.3
Mixed	45	15.2	7.2	-8.3	25.4	14	3.7	10.7	-26.1	18.4	17	22.8	10.7	13.1	54.2	44	17.6	7.8	1.8	35.3
Rain	173	11.9	9.9	-26.5	29.3	137	15.3	9.1	-31.0	29.1	66	11.2	13.5	-23.8	46.4	152	7.8	10.1	-25.2	29.6
Snow	120	12.5	8.5	-22.2	31.1	32	9.7	8.9	-19.3	22.4	32	18.4	8.0	7.1	45.7	76	11.3	10.9	-25.4	31.3

Table S2: Stepwise regression equations for the meteorological seasons linking $\delta^{18}O$, δD, and D-excess with latitude, longitude, and elevation.

Season	$\delta^{18}O$	δD	D-excess
DJF	$\delta^{18}O_{DJF} = -15.8 - 0.04Lat + 0.15Lon - 0.005E$	$\delta D_{DJF} = -223 + 1.94Lat + 1.57Lon - 0.04E$	$D\text{-}excess_{DJF} = -96.5 + 2.26Lat + 0.34Lon - 0.007E$
MAM	$\delta^{18}O_{MAM} = 51.8 - 0.84Lat - 0.29Lon - 0.002E$	$\delta D_{MAM} = 427 - 5.84Lat - 2.94Lon - 0.009E$	$D\text{-}excess_{MAM} = 12.8 + 0.89Lat - 0.61Lon - 0.002E$
JJA	$\delta^{18}O_{JJA} = 30.3 - 0.66Lat - 0.01Lon - 0.002E$	$\delta D_{JJA} = 302 - 7.89Lat + 0.49Lon - 0.01E$	$D\text{-}excess_{JJA} = 58.9 - 2.59Lat + 0.59Lon + 0.001E$
SON	$\delta^{18}O_{SON} = -29.9 - 2.02Lat + 1.51Lon - 0.004E$	$\delta D_{SON} = -306 - 16.97Lat + 13.9Lon - 0.04E$	$D\text{-}excess_{SON} = -66.4 - 0.83Lat + 1.80Lon - 0.01E$

Table S3: Mean isotopic ratios for the warm (May-October) and cold (November-April) periods for all samples; δ_w – warm period (May-October); δ_c – cold period (November-April).

Period	Oxygen, ‰				Hydrogen, ‰			
	UA	CKS	AA	CHK	UA	CKS	AA	CHK
May-October	-6.9	-6.0	-4.1	-2.3	-42.8	-33.0	-22.5	-14.1
November-April	-15.5	-13.0	-12.1	-10.8	-111.6	-96.7	-77.4	-73.2
$\delta_w - \delta_c$	8.6	7.0	8.0	8.5	68.8	63.7	54.9	59.1

Table S4: Correlation between $\delta^{18}O$ and δD and air temperature for each sampling site. Coefficients of determination are statistically significant at 95% confidence level at all sites except Tashkent.

Sampling site	$\delta^{18}O$		δD	
	Equation	R^2	Equation	R^2
Bolshoe Almatinskoe Lake (BAL)	$\delta^{18}O_{Annual} = 0.69t - 10.45$	0.59	$\delta D_{Annual} = 5.33t - 70.76$	0.60
Lesnoy Cordon	$\delta^{18}O_{Annual} = 0.67t - 11.72$	0.46	$\delta D_{Annual} = 5.50t - 81.25$	0.49
Baityk	$\delta^{18}O_{Annual} = 0.60t - 11.35$	0.66	$\delta D_{Annual} = 4.10t - 72.33$	0.59
Tashkent	$\delta^{18}O_{Annual} = 0.32t - 9.06$	0.27	$\delta D_{Annual} = 2.46t - 61.53$	0.27
Pskem	$\delta^{18}O_{Annual} = 0.55t - 9.85$	0.54	$\delta D_{Annual} = 3.79t - 63.08$	0.47
Oygaing	$\delta^{18}O_{Annual} = 0.74t - 10.09$	0.64	$\delta D_{Annual} = 5.50t - 81.25$	0.56

Table S5: Summary of the OLSR calculations. SE is standard error.

Territory	Slope	SE	Intersept	SE	R^2	n
CA (all samples)	7.57	0.05	8.71	0.55	0.96	909
CA (DJF)	8.10	0.13	13.78	2.06	0.95	179
CA (MAM)	7.75	0.09	10.52	0.88	0.97	291
CA (JJA)	6.17	0.12	2.66	0.70	0.90	297
CA (SON)	7.72	0.12	13.50	1.53	0.97	142
CA (rain)	6.64	0.09	4.74	0.58	0.91	529
CA (mixed)	7.73	0.25	13.21	2.57	0.89	120
CA (snow)	7.95	0.11	11.77	1.74	0.96	260
UA (all samples)	7.56	0.07	8.41	0.82	0.97	338
UA (DJF)	7.69	0.23	3.52	4.49	0.97	37
UA (MAM)	8.04	0.17	14.89	2.04	0.97	82
UA (JJA)	6.27	0.14	2.36	0.91	0.93	141
UA (SON)	7.50	0.15	9.55	1.95	0.97	78
UA (rain)	6.29	0.13	2.63	0.88	0.93	173
UA (mixed)	7.16	0.28	8.09	2.55	0.94	45
UA (snow)	7.83	0.13	9.88	2.22	0.97	120
CKS (all samples)	7.87	0.14	12.42	1.29	0.95	183
CKS (DJF)	6.68	0.52	-12.14	8.04	0.91	17
CKS (MAM)	8.41	0.24	15.57	2.63	0.96	60
CKS (JJA)	6.54	0.26	8.16	1.46	0.89	85
CKS (SON)	7.60	0.35	15.79	3.33	0.96	21
CKS (rain)	7.09	0.19	10.02	1.30	0.91	137
CKS (mixed)	5.21	0.50	-28.33	5.90	0.89	14
CKS (snow)	7.46	0.35	1.58	5.54	0.93	32
AA (all samples)	7.01	0.15	6.62	1.64	0.95	115
AA (DJF)	8.05	0.35	21.36	5.01	0.95	30
AA (MAM)	7.69	0.19	12.13	1.89	0.98	37
AA (JJA)	6.09	0.48	0.96	2.29	0.85	28
AA (SON)	7.25	0.53	14.00	5.99	0.91	20
AA (rain)	6.08	0.28	3.00	1.72	0.88	66
AA (mixed)	5.74	1.65	-1.05	17.56	0.41	17
AA (snow)	8.08	0.35	19.65	5.63	0.95	32
CHK (all samples)	7.66	0.09	7.65	0.99	0.96	272
CHK (DJF)	8.38	0.18	16.74	2.51	0.96	95
CHK (MAM)	7.45	0.16	8.17	1.23	0.95	112
CHK (JJA)	6.15	0.35	-2.00	1.60	0.90	43
CHK (SON)	8.05	0.19	15.53	3.01	0.99	22
CHK (rain)	7.09	0.16	4.11	1.02	0.93	145
CHK (mixed)	8.60	0.29	23.68	3.15	0.95	52
CHK (snow)	8.22	0.20	14.67	3.35	0.96	75

Table S6: The values of slopes, intercepts, and standard deviations from different regression methods applied to the monthly-averaged and event-based data sets. Results of t-test comparing each regression method and OLSR are shown. N is a number of samples. The metrics are as follows: slope of regression line (a), standard deviation of the slope (sa), intercept of regression line (b), standard deviation of the intercept (sb), average value of the sum of the squared errors of three methods OLSR, RMA and MA (or three precipitation weighted) regressions, root mean Sum of Squared Errors (RMSSE), which allow inter-comparison of the different regression methods. The proximity of the RMSSE values to 1.0 is an indicator of the suitability of a used regression method for the analysed data set.

Monthly	N	a	sa	b	sb	RMSSE	t-value	p-value
OLSR	137	7.5778	0.1182	9.7101	1.2355	1.0074		
RMA	137	7.7012	0.1173	10.7859	1.2279	1.0026	0.7378	0.46
MA	137	7.8224	0.1206	11.8433	1.2607	1.0057	1.4549	0.15
PWLSR	137	7.7358	0.1165	12.1886	1.0953	1.0012	0.9331	0.35
PWRMA	137	7.8533	0.1171	13.1535	1.1005	1.0049	1.6181	0.11
PWMA	137	7.9689	0.1182	14.1021	1.111	1.0152	2.2763	0.03
Event-based	N	a	sa	b	sb	RMSSE	t-value	
OLSR	869	7.5606	0.0509	8.8169	0.5436	1.0079		
RMA	869	7.7075	0.0508	10.0619	0.544	1.0031	2.0376	0.04
MA	869	7.8524	0.0518	11.2895	0.5538	1.0078	4.0184	<0.01
PWLSR	869	7.8576	0.0508	14.2822	0.5326	1	3.9999	<0.01
PWRMA	869	7.9987	0.051	15.5161	0.5349	1.0123	5.8342	<0.01
PWMA	869	8.1379	0.0517	16.7339	0.5419	1.0313	7.5758	<0.01

Table S7: The values of slopes and intercepts and standard errors for different regressions methods applied to event-based samples for each catchment. All metrics are as in Table S6.

Ulken Almaty	N	a	sa	b	sb	RMSSE	t-value	p-value
OLSR	332	7.5437	0.0721	8.3315	0.8212	1.0061		
RMA	332	7.6564	0.0718	9.3836	0.8197	1.0024	1.1042	0.27
MA	332	7.767	0.0731	10.4159	0.833	1.006	2.1758	0.03
PWLSR	332	7.8049	0.0748	12.6969	0.8637	1	2.5067	0.01
PWRMA	332	7.9221	0.075	13.8732	0.8669	1.0144	3.591	<0.01
PWMA	332	8.0374	0.0758	15.0299	0.8762	1.0348	4.6175	<0.01
Chon Kyzyl Suu	N	a	sa	b	sb	RMSSE	t-value	
OLSR	149	7.9449	0.1457	14.2324	1.2822	1.0099		
RMA	149	8.139	0.1447	15.6373	1.276	1.0039	0.939	0.35
MA	149	8.332	0.1492	17.0342	1.3126	1.0098	1.8561	0.07
PWLSR	149	8.4272	0.1154	20.8734	1.0011	1	2.2304	0.03
PWRMA	149	8.5426	0.1158	21.7223	1.0045	1.0101	2.7389	0.01
PWMA	149	8.6565	0.117	22.5598	1.0145	1.0231	3.2258	<0.01
Ala Archa	N	a	sa	b	sb	RMSSE	t-value	
OLSR	115	7.0141	0.1545	6.6244	1.641	1.0109		
RMA	115	7.2037	0.1531	8.2119	1.6308	1.0043	0.8652	0.39
MA	115	7.3912	0.1585	9.7814	1.6837	1.0108	1.704	0.09

PWLSR	115	7.117	0.1559	9.4696	1.8109	1.0028	0.4668	0.47
PWRMA	115	7.3073	0.1569	11.3159	1.8228	1.0074	1.3178	0.19
PWMA	115	7.4956	0.1599	13.1428	1.8576	1.0243	2.1311	0.04
Chirchik	N	a	sa	b	sb	RMSSE	t-value	
OLSR	272	7.6396	0.0885	7.4144	0.954	1.0073		
RMA	272	7.7767	0.0881	8.5341	0.9523	1.0029	1.0933	0.28
MA	272	7.9117	0.09	9.6371	0.9706	1.0072	2.1562	0.03
PWLSR	272	7.7797	0.0869	11.3965	0.9194	1.0013	1.0966	0.27
PWRMA	272	7.9097	0.0873	12.4983	0.9232	1.0056	2.0997	0.04
PWMA	272	8.0376	0.0883	13.5835	0.9342	1.0166	3.064	<0.01

Table S8: The values of slopes and intercepts and standard errors for different regressions methods applied to the event-based precipitation in different seasons. All metrics are as in Table S6.

Event-based DJF	N	a	sa	b	sb	rmSSEav	t-value	p-value
OLSR	168	8.1417	0.1354	14.6149	2.073	1.0092		
RMA	168	8.3266	0.1346	17.1842	2.0626	1.0036	0.9626	0.34
MA	168	8.5104	0.1384	19.738	2.1187	1.0091	1.9036	0.06
PWLSR	168	8.0465	0.1349	15.2372	1.992	1.018	0.4931	0.62
PWRMA	168	8.2321	0.1357	17.7164	2.0034	1.0048	0.4685	0.64
PWMA	168	8.4165	0.1379	20.1798	2.0367	1.0031	1.4176	0.16
Event-based MAM	N	a	sa	b	sb	rmSSEav	t-value	
OLSR	273	7.7301	0.0867	10.7352	0.8727	1.0069		
RMA	273	7.8607	0.0863	11.855	0.8705	1.0027	1.0629	0.29
MA	273	7.9892	0.0881	12.9578	0.887	1.0068	2.0968	0.04
PWLSR	273	8.0178	0.0826	14.5088	0.8818	1	2.3071	0.02
PWRMA	273	8.1324	0.0829	15.5757	0.8849	1.0127	3.1927	<0.01
PWMA	273	8.2451	0.0838	16.6258	0.894	1.0304	4.0353	<0.01
Event-based JJA	N	a	sa	b	sb	rmSSEav	t-value	
OLSR	290	6.2077	0.1185	2.8686	0.6886	1.0205		
RMA	290	6.5255	0.1181	4.1605	0.6906	1.0079	1.8841	0.06
MA	290	6.8446	0.1243	5.4575	0.7223	1.0202	3.7075	<0.01
PWLSR	290	6.8188	0.135	9.7689	0.843	1	3.3468	<0.01
PWRMA	290	7.1934	0.1368	11.7214	0.8542	1.0444	5.1796	<0.01
PWMA	290	7.5739	0.1422	13.705	0.8876	1.1069	6.8131	<0.01
Event-based SON	N	a	sa	b	sb	rmSSEav	t-value	
OLSR	138	7.7143	0.1222	13.2973	1.5572	1.0069		

RMA	138	7.8448	0.1213	14.7225	1.5476	1.0027	0.7534	0.45
MA	138	7.9732	0.1242	16.1258	1.5826	1.0068	1.4862	0.14
PWLSR	138	8.0415	0.1261	19.119	1.7186	1	1.8438	0.07
PWRMA	138	8.1749	0.1266	20.7757	1.7256	1.0194	2.5579	0.01
PWMA	138	8.3065	0.1281	22.4107	1.7463	1.0453	3.2302	<0.01

Table S9: The values of slopes, intercepts and standard errors for different regressions methods applied each type of precipitation. All metrics are as in Table S6.

Rain	N	a	sa	b	sb	rmSSEav	t-value	p-value
OLSR	514	6.6615	0.0889	4.9455	0.5849	1.0179		
RMA	514	6.9574	0.0887	6.4088	0.5865	1.0069	2.341	0.02
MA	514	7.2541	0.0927	7.8765	0.6099	1.0176	4.6148	<0.01
PWLSR	514	7.3314	0.0935	11.6977	0.6652	1	5.0051	<0.01
PWRMA	514	7.6294	0.0944	13.4627	0.6718	1.0365	7.006	<0.01
PWMA	514	7.9292	0.0972	15.2385	0.6914	1.0856	8.8251	<0.01
Mixed	N	a	sa	b	sb	rmSSEav	t-value	
OLSR	113	7.6191	0.2487	12.7937	2.5384	1.0233		
RMA	113	8.057	0.2465	16.9766	2.5202	1.009	1.2366	0.22
MA	113	8.5065	0.2626	21.2692	2.6801	1.0231	2.4537	0.02
PWLSR	113	7.9792	0.2094	16.1732	2.1009	1.006	1.0192	0.31
PWRMA	113	8.2785	0.2113	18.9864	2.1201	1.0091	1.8458	0.07
PWMA	113	8.5802	0.217	21.8225	2.1775	1.0243	2.645	<0.01
Snow	N	a	sa	b	sb	rmSSEav	t-value	
OLSR	241	7.995	0.1086	12.7211	1.7801	1.0089		
RMA	241	8.1708	0.1081	15.4332	1.7738	1.0035	1.1415	0.25
MA	241	8.3452	0.1109	18.1239	1.8181	1.0088	2.256	0.02
PWLSR	241	7.9762	0.1174	14.1555	1.9575	1.0085	0.1214	0.90
PWRMA	241	8.1817	0.1181	17.4222	1.9699	1.0036	1.2004	0.23
PWMA	241	8.3862	0.1203	20.6755	2.0065	1.0128	2.4886	0.01

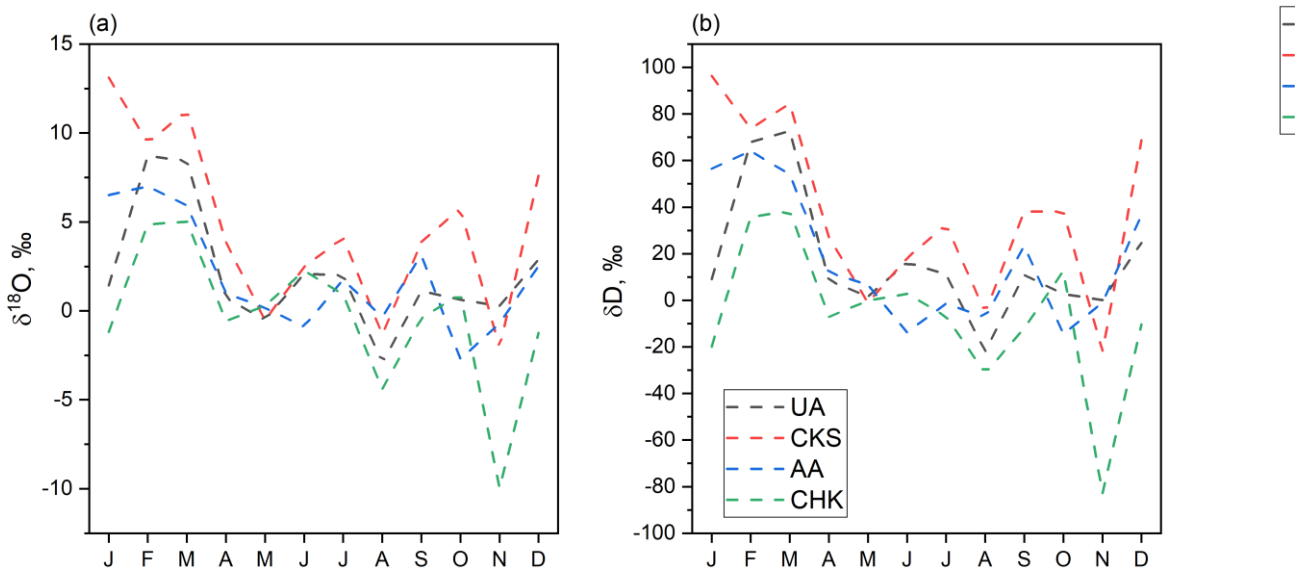

Figure S1: The difference between the data from the Waterisotopes Database and data obtained in this study for (a) $\delta^{18}O$; (b) δD

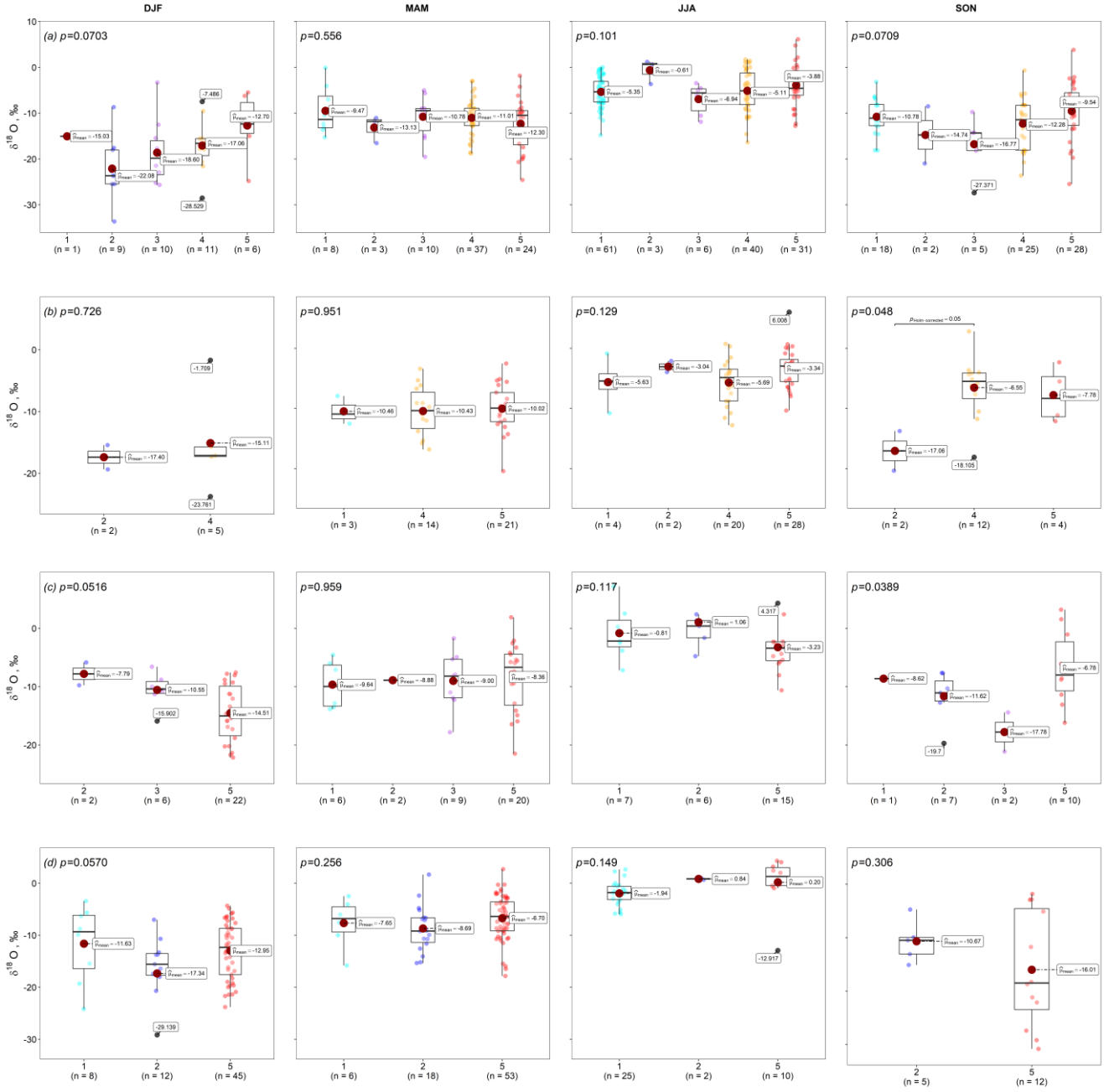

Figure S2: Values of $\delta^{18}O$ for each original cluster for each site and season: (a) UA; (b) CKS; (c) AA; (d) CHK.

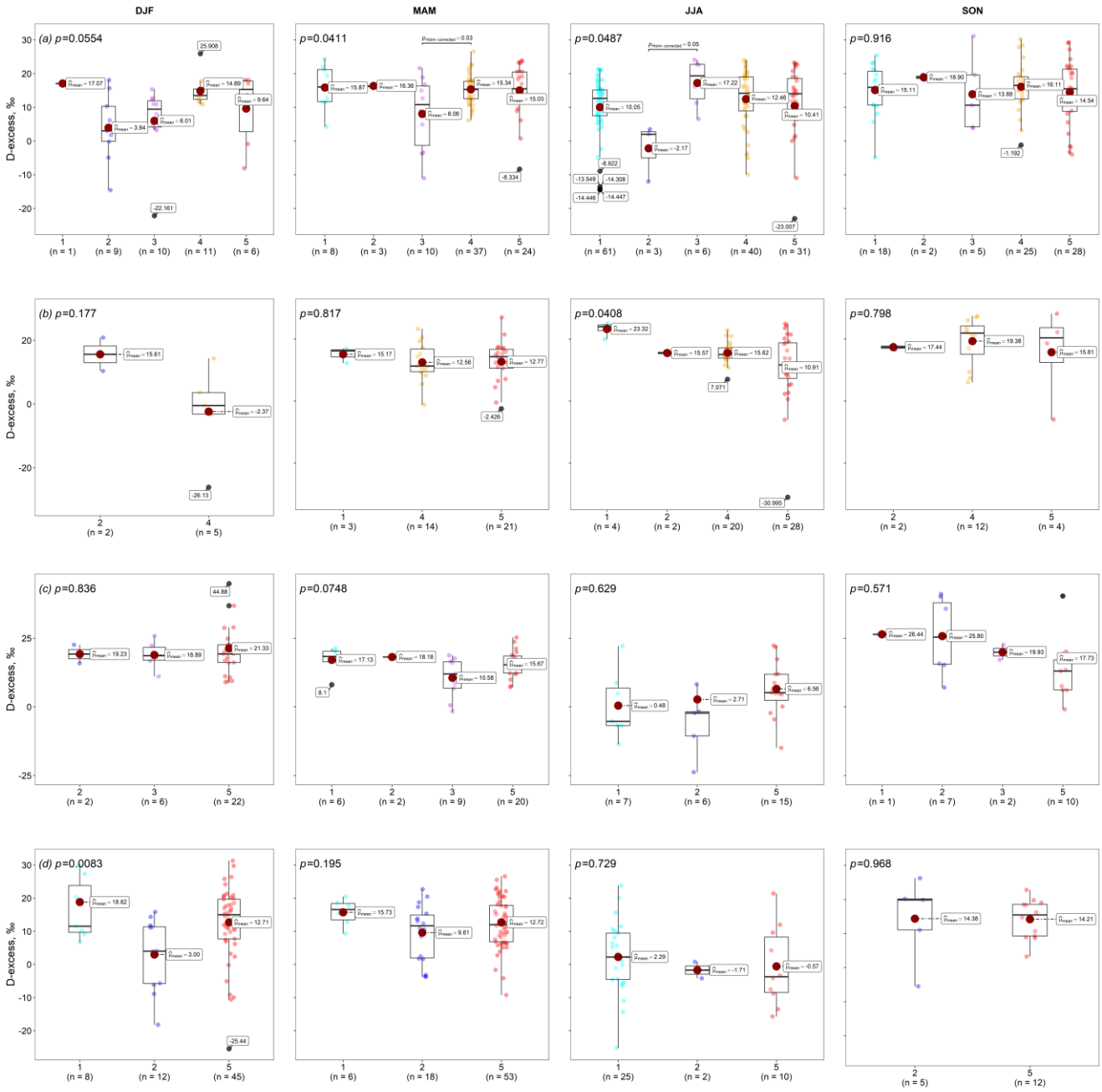

Figure S3: Values of D-excess for each original cluster for each site and season: (a) UA; (b) CKS; (c) AA; (d) CHK.