

## Seasonal temperature and moisture changes in interior semi-arid Spain from the last interglacial to the late Holocene: Supplementary Information

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This supplementary contains the following figures and tables:

SI Figure 1. The impact of removing Poaceae and Polypodiales from the taxon set on reconstructions of (a) mean temperature of the coldest month (MTCO, °C) and (b) growing degree days above a base level of 0°C (GDD0) during MIS 4 and MIS 5a. The red line (without P/P) is the reconstructed values once Poaceae and Polypodiales are removed. The comparison shows that removing these two taxa reduces anomalous peaks, where they were particularly abundant, but has little impact on the reconstructions for the rest of the samples.

SI Figure 2. Reconstructed mean temperature of the coldest month (MTCO, °C), growing degree days above a base level of 0°C (GDD0) and square root of the moisture index (the ratio of annual precipitation to annual potential evapotranspiration, MI) after CO<sub>2</sub> correction. This plot differs from Figure 5 in the main text because the reconstructions for all of the samples are shown, and we show the full uncertainties rather than the sample-specific (*v1*, *rioja*) uncertainties. The Marine Isotope Stages (MIS) and substages are shown by vertical dotted lines and labeled; we also show the transition interval between MIS 6 and MIS 5e. Red dots indicate the modern climate calculated from the elevation-corrected climate data from the Climate Research Unit (CRU) 2.0 data set.

SI Figure 3: Identification of reconstructed climate changes during selected Dansgaard-Oeschger and Heinrich events. Reconstructed mean temperature of the coldest month (MTCO, °C), growing degree days above a base level of 0°C (GDD0) and CO<sub>2</sub> corrected moisture index (the ratio of annual precipitation to annual potential evapotranspiration, MI). Only samples with a Hill's N<sub>2</sub> biodiversity index >2 are plotted. The Marine Isotope Stages (MIS) and substages are shown by vertical dotted lines and labeled; we also show the transition interval between MIS 6 and MIS 5e. Red dots indicate the modern climate calculated from the elevation-corrected climate data from the Climate Research Unit (CRU) 2.0 data set.

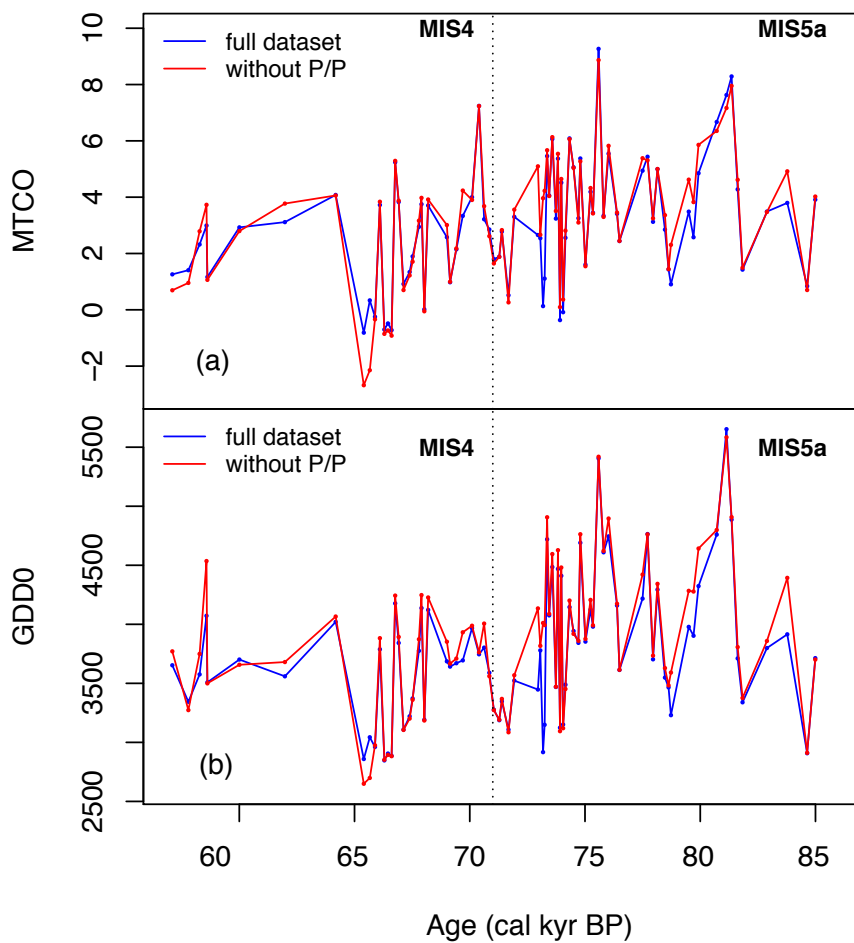
SI Table 1: Information on the 195 taxa from the SMPDS modern data set used in the TWA-PLS reconstructions, including the number of sites at which they occur and their taxonomic resolution.

SI Table 2: Leave-one-out cross-validated predictions of the weighted averaging-partial least squares (WA-PLS) regression models for 195 taxa (including Poaceae and Polypodiales). The P values are derived from a randomisation *t*-test. Selected components are marked in bold.

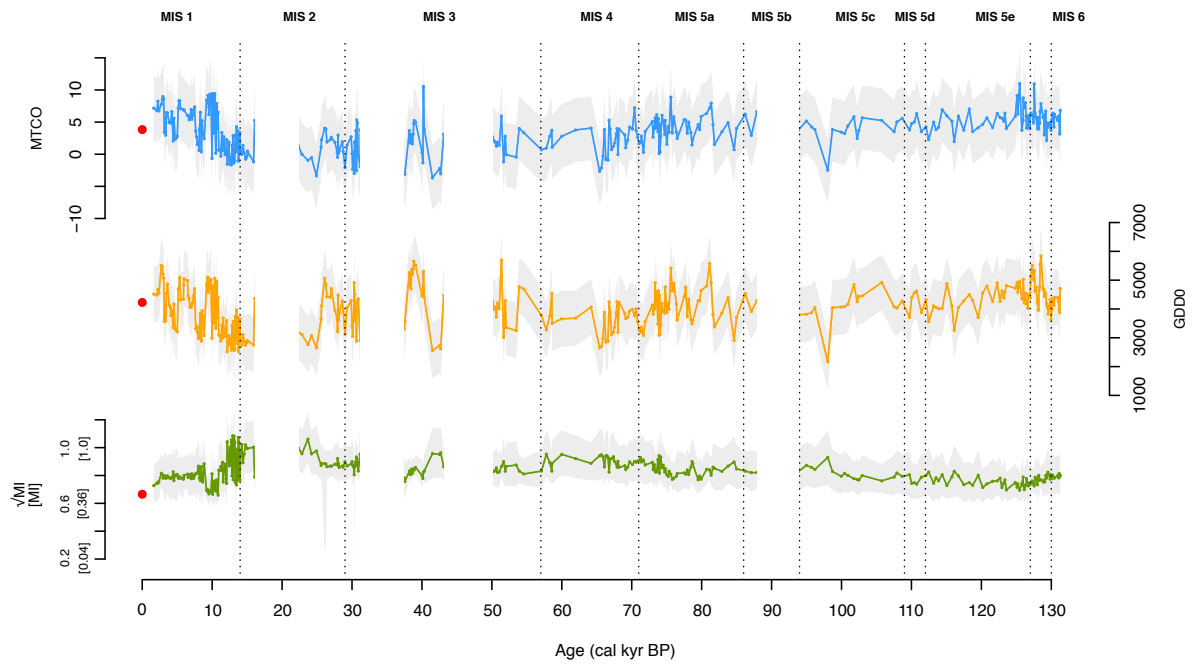
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SI Table 4: Reconstructed average values of mean temperature of the coldest month (MTCO, °C), growing degree days above a base level of 0° C (GDD<sub>0</sub>) and moisture index (the ratio of annual precipitation to annual potential evapotranspiration, MI) for Marine Isotope Stages (MIS ) and substages, calculated from the interpolated yearly values of each variable. The transitional phase at the beginning of MIS 5 corresponding to the Zeifen-Kattegat Oscillation is labelled Zeifen in the column showing the Marine Isotopic Stages.

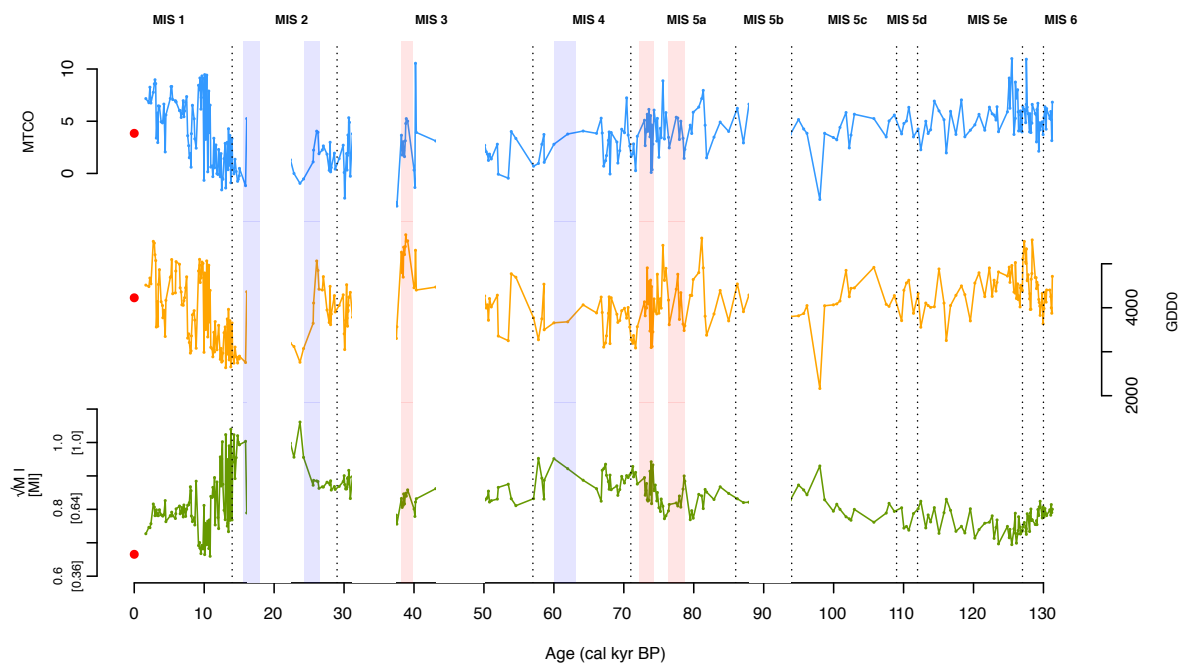
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SI Table 1: Information on the 195 taxa from the SMPDS modern data set used in the TWA-PLS reconstructions, including the number of sites at which they occur and their taxonomic resolution.

<b>Taxon name</b>	<b>Number of sites</b>	<b>Taxonomic resolution</b>
Abies	2410	Genus
Acer	981	Genus
Aconitum	110	Genus
Adonis	25	Genus
Aesculus	70	Genus
Alnus	4863	Genus
Alnus.alnobetula	511	Species
Amaranthaceae	4612	Family
Amaryllidaceae	47	Family
Amygdaloideae	49	Subfamily
Andromeda	28	Genus
Apiaceae	3784	Family
Aquilegia	29	Genus
Arbutus	179	Genus
Arctostaphylos	78	Genus
Argania	82	Genus
Artemisia	4522	Genus
Asparagaceae	42	Family
Asteraceae	462	Family
Asteroideae	4149	Subfamily
Astragalus	183	Genus
Berberis	26	Genus
Betula	4309	Genus
Betula.Chamaebetula	375	Subgenus
Boraginaceae	840	Family
Brassicaceae	3233	Family
Bruckenthalia	28	Genus
Buxus	216	Genus
Calluna	1293	Genus
Campanulaceae	687	Family
Caprifoliaceae	793	Family
Caragana	20	Genus
Carduoideae	1692	Subfamily
Carpinus.betulus	2210	Species
Carpinus.orientalis+Ostrya	604	Species plus genus
Caryophyllaceae	2998	Family
Cassiope	11	Genus
Castanea	1671	Genus
Cedrus	457	Genus

Celastraceae	114	Family
Celtis	27	Genus
Ceratonia	36	Genus
Cichorioideae	3160	Subfamily
Cistaceae	148	Family
Cistus	687	Genus
Clematis	66	Genus
Colchicaceae	13	Family
Convolvulaceae	290	Family
Cornus	190	Genus
Corylus	3812	Genus
Cotinus	17	Genus
Crassulaceae	433	Family
Crataegus	157	Genus
Cupressaceae	2961	Family
Cyperaceae	4078	Family
Cytinaceae	11	Family
Daphne	151	Genus
Delphinium	18	Genus
Dennstaedtiaceae	898	Family
Diapensia	12	Genus
Dryas	65	Genus
Empetrum	431	Genus
Ephedra	765	Genus
Equisetum	701	Genus
Erica	707	Genus
Ericaceae	1602	Family
Euonymus	12	Genus
Euphorbiaceae	393	Family
Fabaceae	1924	Family
Fabaceae.herbs	980	Group
Fagus	2247	Genus
Frangula	189	Genus
Fraxinus	2443	Genus
Genisteae	587	Tribe
Gentianaceae	312	Family
Geraniaceae	498	Family
Halimium	53	Genus
Hedera	270	Genus
Helianthemum	775	Genus
Helleborus	13	Genus
Hippophae	87	Genus
Huperzia	218	Genus
Hypericaceae	253	Family

Ilex	171	Genus
Impatiens	38	Genus
Iridaceae	96	Family
Jasminum	20	Genus
Juglans	1639	Genus
Juncaceae	558	Family
Kalmia	34	Genus
Lamiaceae	1671	Family
Larix	979	Genus
Lavandula	144	Genus
Ledum	48	Genus
Liguliflorae	432	Group
Ligustrum	120	Genus
Liliaceae	1024	Family
Linaceae	17	Family
Linnaea	42	Genus
Linum	72	Genus
Lonicera	119	Genus
Lycopodium	826	Genus
Lysimachia	108	Genus
Lythraceae	67	Family
Malus	15	Genus
Malvaceae	108	Family
Melanthiaceae	42	Family
Mercurialis	380	Genus
Montiaceae	11	Family
Moraceae	21	Family
Myrica	224	Genus
Myrtaceae	233	Family
Nartheciaceae	40	Family
Nerium	16	Genus
Nitrariaceae	66	Family
Olea	1968	Genus
Oleaceae	476	Family
Onagraceae	256	Family
Ononis	17	Genus
Ophioglossaceae	295	Family
Orobanchaceae	664	Family
Osmundaceae	49	Family
Oxalidaceae	73	Family
Oxyria+Rumex	3911	Group
Paliurus	47	Genus
Papaveraceae	463	Family
Parrotia	15	Genus



Phillyrea	940	Genus
Picea	3144	Genus
Picea.orientalis	65	Species
Pinus.diploxylon	5422	Subgenus
Pinus.haploxylon	1319	Subgenus
Pistacia	767	Genus
Plantaginaceae	4205	Family
Platanus	391	Genus
Plumbaginaceae	555	Family
Poaceae	5258	Family
Polemoniaceae	724	Family
Polygalaceae	52	Family
Polygonaceae	449	Family
Polygonum	1137	Genus
Polypodiales	3493	Order
Populus	714	Genus
Portulacaceae	12	Family
Potentilla	898	Genus
Primulaceae	350	Family
Prunus	202	Genus
Pteridaceae	174	Family
Pterocarya	58	Genus
Quercus.deciduous	4674	Group
Quercus.evergreen	2129	Group
Quercus.intermediate	45	Group
Ranunculaceae	1871	Family
Ranunculus	1622	Genus
Resedaceae	30	Family
Rhamnaceae	76	Family
Rhamnus	176	Genus
Rhododendron	145	Genus
Rhus	69	Genus
Ribes	44	Genus
Rosaceae	3082	Family
Rosmarinus	43	Genus
Rubiaceae	2054	Family
Rubus	438	Genus
Ruscus	13	Genus
Salix	3224	Genus
Salvia	16	Genus
Sambucus	834	Genus
Sanguisorba.group	666	Group
Santalaceae	65	Family
Saxifragaceae	481	Family

Scrophulariaceae	1407	Family
Solanaceae	219	Family
Sorbus	402	Genus
Styrax	30	Genus
Tamarix	78	Genus
Taxus	182	Genus
Teucrium	81	Genus
Thalictrum	693	Genus
Thymelaeaceae	95	Family
Tilia	1505	Genus
Tofieldia	21	Genus
Trollius	150	Genus
Ulmus	2041	Genus
Ulmus+Zelkova	31	Group
Urticaceae	2318	Family
Vaccinium	765	Genus
Valerianaceae	266	Family
Verbenaceae	19	Family
Viburnum	266	Genus
Violaceae	149	Family
Viscum	74	Genus
Vitex	11	Genus
Ziziphus	19	Genus
Zygophyllaceae	254	Family

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SI Table 2: Leave-one-out cross-validated predictions of the weighted averaging-partial least squares (WA-PLS) regression models for 195 taxa (including Poaceae and Polypodiales). The P values are derived from a randomisation *t*-test. Selected components are marked in bold.

<b>TWA-PLS component</b>	<b>RMSEP</b>	<b>r<sup>2</sup></b>	<b>P</b>
<b>MTCO</b>			
1	5.51	0.67	0.001
<b>2</b>	<b>5.4</b>	<b>0.7</b>	<b>0.009</b>
3	5.97	0.64	1
4	6.55	0.6	1
<b>GDD<sub>0</sub></b>			
<b>1</b>	<b>958.35</b>	<b>0.66</b>	<b>0.001</b>
2	982.51	0.68	0.987
3	1091.43	0.65	1
4	1186.17	0.62	1
<b>√MI</b>			
1	0.49	0.45	0.001
<b>2</b>	<b>0.48</b>	<b>0.52</b>	<b>0.001</b>
3	0.49	0.5	1
4	0.51	0.46	1

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Depth (cm)	Age (cal yr BP)	Mean temperature of the coldest month (°C)	Growing degree days above zero	Reconstructed $\sqrt{\text{MI}}$	Corrected $\sqrt{\text{MI}}$	Upper limit corrected $\sqrt{\text{MI}}$	Lower limit corrected $\sqrt{\text{MI}}$
40	1655.9	7.17±0.59	4515±36	0.58±0.02	0.73	0.02	0.02
49	2093.5	6.77±0.59	4482±34	0.6±0.01	0.75	0.01	0.01
52	2239.4	8.26±0.42	4676±35	0.57±0.02	0.75	0.02	0.02
55	2385.3	6.74±0.25	4542±27	0.61±0.01	0.76	0.01	0.01
62	2725.7	7.77±0.56	5510±51	0.57±0.02	0.82	0.02	0.02
65	2871.7	8.58±0.83	5471±71	0.56±0.02	0.81	0.02	0.02
67	2968.9	8.97±0.96	5205±75	0.55±0.03	0.78	0.03	0.03
69	3066.1	8.6±1.12	5073±90	0.59±0.03	0.79	0.03	0.03
71	3163.4	3.38±0.22	3562±21	0.76±0.01	0.80	0.01	0.01
74	3309.3	5.79±0.39	4142±26	0.68±0.01	0.78	0.01	0.01
75	3358	2.96±0.21	3579±22	0.74±0.01	0.79	0.01	0.01
77	3455.3	6.47±0.43	4530±30	0.64±0.01	0.78	0.01	0.01
80	3601.1	6.43±0.3	4866±29	0.62±0.01	0.80	0.01	0.01
85	3844.3	4.94±0.28	4138±22	0.68±0.01	0.78	0.01	0.01
89	4038.9	4.84±0.29	4050±23	0.69±0.01	0.78	0.01	0.01
90	4087.5	4.98±0.38	3772±24	0.71±0.01	0.78	0.01	0.01
93	4233.3	6.64±0.9	3944±50	0.7±0.02	0.78	0.03	0.03
97	4427.9	2.06±0.24	3347±25	0.8±0.01	0.83	0.01	0.01
99	4525.1	5.6±0.46	4168±27	0.65±0.01	0.76	0.01	0.01
112	5157.3	7.18±0.79	4689±52	0.6±0.02	0.78	0.02	0.02
114	5254.5	8.31±0.86	4715±57	0.6±0.02	0.78	0.03	0.02
116	5351.9	8.33±0.74	5097±55	0.56±0.02	0.79	0.02	0.02
119	5497.7	7.07±0.65	4318±39	0.64±0.02	0.78	0.02	0.02
127	5886.7	6.96±0.5	4338±30	0.63±0.02	0.77	0.02	0.02
128	5935.4	6.91±0.32	4835±28	0.58±0.01	0.79	0.01	0.01
129	5984.1	6.84±0.33	5049±29	0.58±0.01	0.80	0.01	0.01
139	6470.4	6.01±0.3	4990±28	0.59±0.01	0.81	0.01	0.01
141	6567.6	6.02±0.23	4455±21	0.62±0.01	0.79	0.01	0.01
144	6713.5	5.36±0.35	4359±26	0.64±0.01	0.79	0.01	0.01
146	6810.9	5.72±0.55	4067±32	0.69±0.01	0.81	0.02	0.02
150	7005.4	6.97±0.96	4057±52	0.66±0.02	0.78	0.03	0.03
152	7102.6	5.43±0.46	4160±28	0.69±0.01	0.81	0.02	0.02
154	7199.9	5.98±0.52	4228±32	0.67±0.01	0.80	0.02	0.02
157	7345.8	6.81±0.54	4454±34	0.61±0.02	0.78	0.02	0.02
160	7491.9	7.36±0.71	4703±48	0.61±0.02	0.80	0.02	0.02

163	7637.8	3.61±0.49	3309±23	0.77±0.01	0.81	0.02	0.02
166	7783.9	2.66±0.4	3407±24	0.76±0.01	0.81	0.01	0.01
168	7881.1	1.5±0.28	3210±23	0.79±0.01	0.82	0.01	0.01
171	8027.1	1.91±0.6	2969±28	0.86±0.01	0.87	0.02	0.02
173	8124.3	0.6±0.26	3020±24	0.84±0.01	0.86	0.01	0.01
174	8173	3.8±0.64	3360±29	0.73±0.01	0.78	0.02	0.02
177	8319	6.53±1.2	3839±65	0.66±0.03	0.76	0.04	0.04
182	8562.3	5.23±0.81	3933±40	0.67±0.02	0.77	0.02	0.02
184	8659.5	3.31±0.54	3720±28	0.67±0.01	0.75	0.01	0.01
188	8854.2	2.42±0.61	3080±32	0.87±0.01	0.88	0.03	0.03
195	9194.8	8.44±1.05	4836±58	0.42±0.04	0.69	0.03	0.03
198	9340.7	8±0.97	5100±55	0.39±0.03	0.70	0.02	0.02
199	9389.3	9.14±1.24	4967±69	0.38±0.05	0.68	0.04	0.03
200	9437.9	8.25±1.14	4574±56	0.46±0.05	0.68	0.04	0.04
202	9535.1	6.16±0.89	4764±48	0.4±0.03	0.67	0.02	0.02
203	9583.8	7.26±0.92	4680±47	0.44±0.04	0.68	0.03	0.03
205	9681	9.34±1.09	5039±61	0.39±0.05	0.69	0.03	0.03
208	9827	9.12±1.24	5008±67	0.38±0.05	0.68	0.04	0.03
211	9973.1	-0.66±0.21	2987±23	0.81±0.01	0.81	0.01	0.01
213	10070	9.46±1.4	4791±71	0.39±0.06	0.66	0.04	0.04
216	10216	3.26±0.33	3504±24	0.71±0.01	0.76	0.02	0.02
219	10362	9.42±1.18	5065±66	0.39±0.05	0.69	0.04	0.03
222	10508	0.16±0.23	3336±25	0.73±0.01	0.76	0.01	0.01
225	10654	7.89±1.04	4966±57	0.39±0.04	0.68	0.03	0.03
227	10751	3.91±0.49	3676±28	0.7±0.01	0.77	0.02	0.02
229	10848	6.54±0.99	4394±46	0.46±0.04	0.66	0.03	0.03
231	10945	0.61±0.28	3100±28	0.83±0.01	0.84	0.02	0.02
235	11140	0.73±0.27	3065±27	0.83±0.01	0.84	0.02	0.02
237	11237	-0.3±0.31	2884±29	0.87±0.01	0.87	0.02	0.02
240	11383	3.37±0.24	3441±32	0.79±0.01	0.84	0.02	0.02
242	11481	0.54±0.45	2995±42	0.89±0.01	0.90	0.03	0.02
244	11578	2.37±0.45	3685±35	0.67±0.01	0.75	0.02	0.02
246	11675	2.73±0.45	3294±40	0.79±0.02	0.83	0.03	0.03
249	11821	-0.01±0.3	3044±34	0.86±0.01	0.88	0.02	0.02
252	11967	-0.1±0.35	3339±31	0.72±0.01	0.78	0.02	0.02
254	12064	2.3±0.6	3600±42	0.65±0.02	0.74	0.03	0.03
259	12307	-0.31±0.4	2826±47	0.94±0.02	0.96	0.03	0.03
261	12404	1.9±0.57	3075±42	0.83±0.02	0.87	0.04	0.04
264	12505	-1.57±0.34	2765±42	0.94±0.01	0.95	0.03	0.03
267	12605	-0.46±0.41	2791±52	0.98±0.02	1.00	0.03	0.03
269	12672	-0.56±0.28	2968±28	0.84±0.01	0.87	0.02	0.02
274	12839	1.41±0.53	3432±41	0.7±0.02	0.80	0.03	0.03
279	13006	2.88±0.71	3563±36	0.65±0.03	0.77	0.03	0.03
281	13073	-1.39±0.39	2637±49	1.01±0.02	1.02	0.03	0.03
288	13307	2.99±0.67	3746±38	0.6±0.03	0.75	0.03	0.03
290	13374	2.8±0.58	3619±32	0.63±0.02	0.76	0.03	0.02

291	13408	0.36±0.37	2945±44	0.91±0.02	0.95	0.03	0.03
293	13475	4.28±0.9	3964±51	0.55±0.04	0.73	0.04	0.03
296	13575	0.78±0.42	2815±51	0.96±0.02	0.99	0.04	0.04
299	13675	3.64±0.64	3708±38	0.63±0.03	0.77	0.03	0.03
303	13809	-0.88±0.42	2656±54	1.03±0.02	1.04	0.04	0.04
306	13909	2.41±0.59	3096±52	0.86±0.03	0.91	0.05	0.04
308	13976	3.34±0.57	3655±32	0.64±0.02	0.77	0.03	0.02
311	14077	0.44±0.32	2898±39	0.91±0.01	0.94	0.02	0.02
316	14244	-0.04±0.42	2741±56	1±0.02	1.02	0.04	0.04
321	14411	1.36±0.45	3105±49	0.83±0.02	0.89	0.03	0.03
326	14578	0.19±0.37	2882±47	0.91±0.02	0.95	0.03	0.03
332	14779	-0.75±0.43	2743±55	0.99±0.02	1.02	0.04	0.04
335	14879	-0.56±0.36	2872±48	0.96±0.02	1.00	0.03	0.03
339	15012	-0.23±0.3	2837±38	0.95±0.01	0.99	0.02	0.02
340	15046	0.49±0.4	2899±49	0.94±0.02	0.99	0.03	0.03
366	15918	-1.17±0.31	2755±40	0.95±0.01	1.00	0.02	0.02
371	16085	5.25±0.59	4363±42	0.52±0.02	0.79	0.02	0.02
581	22328	1.31±0.34	3194±35	0.84±0.01	1.00	0.02	0.02
604	22836	0±0.22	3118±25	0.8±0.01	0.96	0.01	0.01
643	23698	-0.95±0.3	2761±38	0.94±0.01	1.06	0.02	0.02
666	24206	-0.53±0.21	3072±25	0.8±0.01	0.96	0.01	0.01
728	25578	1.11±0.29	3646±27	0.63±0.01	0.87	0.01	0.01
731	25644	2.24±0.3	4107±39	0.6±0.01	0.89	0.01	0.01
751	26087	4.05±0.43	5064±59	0.45±0.02	0.89	0.01	0.01
759	26264	3.94±0.38	4848±52	0.49±0.02	0.88	0.01	0.01
770	26414	1.89±0.31	4422±38	0.51±0.01	0.86	0.01	0.01
811	26897	2.26±0.32	4404±41	0.53±0.01	0.87	0.01	0.01
823	27039	2.64±0.34	4707±43	0.48±0.01	0.87	0.01	0.01
867	27558	1.85±0.27	3949±35	0.61±0.01	0.88	0.01	0.01
894	27876	0.3±0.25	3665±30	0.64±0.01	0.88	0.01	0.01
905	28006	2.98±0.32	4486±43	0.53±0.01	0.87	0.01	0.01
911	28077	0.16±0.24	3615±30	0.66±0.01	0.89	0.01	0.01
919	28171	0.56±0.21	3856±28	0.59±0.01	0.86	0.01	0.01
957	28619	1.94±0.31	4276±39	0.55±0.01	0.87	0.01	0.01
967	28737	0.42±0.27	3905±34	0.59±0.01	0.86	0.01	0.01
1019	29301	1.42±0.29	4052±36	0.58±0.01	0.87	0.01	0.01
1117	29877	2.7±0.33	4294±40	0.58±0.01	0.88	0.02	0.02
1141	30018	0.09±0.21	3407±24	0.71±0.01	0.90	0.01	0.01
1153	30088	-2.37±0.16	3049±22	0.73±0.01	0.87	0.01	0.01
1177	30228	0.36±0.22	3712±28	0.62±0.01	0.86	0.01	0.01
1201	30367	1.91±0.28	4524±41	0.5±0.01	0.86	0.01	0.01
1211	30426	0.32±0.27	3764±32	0.62±0.01	0.87	0.01	0.01
1223	30495	1.73±0.25	3580±25	0.68±0.01	0.89	0.01	0.01
1233	30555	3.68±0.28	3915±25	0.64±0.01	0.90	0.01	0.01
1235	30567	1.96±0.2	3948±29	0.61±0.01	0.87	0.01	0.01
1245	30624	3.37±0.23	4055±25	0.61±0.01	0.88	0.01	0.01

1253	30671	5.33±0.43	4242±27	0.64±0.01	0.92	0.01	0.01
1263	30768	4.89±0.34	4241±25	0.6±0.01	0.90	0.01	0.01
1268	30897	-0.27±0.31	4349±48	0.48±0.01	0.83	0.01	0.01
1280	31203	3.8±0.6	3783±33	0.66±0.01	0.90	0.02	0.02
1540	37482	-2.82±0.24	3302±28	0.63±0.01	0.78	0.01	0.01
1546	37551	-3.13±0.26	3567±32	0.56±0.01	0.76	0.01	0.01
1603	38202	3.66±0.41	5264±51	0.39±0.02	0.83	0.02	0.01
1613	38313	1.76±0.31	4797±44	0.42±0.02	0.81	0.01	0.01
1624	38433	1.84±0.46	5217±54	0.36±0.02	0.82	0.01	0.01
1626	38458	3.04±0.29	4697±38	0.45±0.01	0.81	0.01	0.01
1632	38523	2.18±0.4	5378±50	0.4±0.02	0.85	0.01	0.01
1643	38643	1.61±0.53	5209±58	0.35±0.03	0.82	0.02	0.01
1653	38756	3.12±0.34	5392±49	0.38±0.02	0.84	0.01	0.01
1659	38822	4.78±0.37	5659±54	0.33±0.02	0.85	0.01	0.01
1666	38899	5.25±0.52	5514±57	0.34±0.03	0.84	0.02	0.01
1683	39089	5.01±0.38	5522±55	0.39±0.02	0.86	0.01	0.01
1766	40011	0.32±0.28	4454±43	0.45±0.01	0.80	0.01	0.01
1777	40128	-1.34±0.38	4501±56	0.4±0.01	0.78	0.01	0.01
1785	40214	10.55±1.84	5307±96	0.32±0.07	0.82	0.04	0.03
1796	40328	3.93±0.46	4403±34	0.51±0.02	0.83	0.01	0.01
2038	43112	3.11±0.21	4470±34	0.57±0.01	0.86	0.01	0.01
2501	50103	2.7±0.28	4269±35	0.56±0.01	0.83	0.01	0.01
2516	50328	2.08±0.22	3994±29	0.61±0.01	0.83	0.01	0.01
2527	50495	1.86±0.19	4067±29	0.6±0.01	0.84	0.01	0.01
2537	50645	1.25±0.2	3716±27	0.67±0.01	0.85	0.01	0.01
2547	50795	1.85±0.27	4209±31	0.57±0.01	0.82	0.01	0.01
2564	51054	1.39±0.22	4018±30	0.6±0.01	0.83	0.01	0.01
2621	51917	2.8±0.36	4286±48	0.57±0.01	0.83	0.02	0.02
2630	52051	-0.07±0.25	3357±31	0.73±0.01	0.87	0.01	0.01
2724	53475	-0.45±0.22	3251±26	0.75±0.01	0.88	0.01	0.01
2753	53908	4.01±0.35	4773±49	0.51±0.02	0.83	0.01	0.01
2790	54567	3.35±0.39	4694±44	0.48±0.02	0.81	0.02	0.02
2924	57095	0.69±0.18	3771±27	0.64±0.01	0.83	0.01	0.01
2961	57791	0.96±0.26	3273±33	0.84±0.01	0.95	0.02	0.02
2987	58279	2.79±0.26	3749±32	0.72±0.01	0.89	0.01	0.01
3003	58577	3.73±0.33	4536±42	0.54±0.02	0.83	0.02	0.02
3005	58616	1.06±0.22	3500±28	0.74±0.01	0.89	0.02	0.01
3079	60003	2.8±0.31	3657±31	0.8±0.01	0.95	0.01	0.01
3185	61979	3.77±0.23	3680±28	0.75±0.01	0.92	0.02	0.02
3319	64182	4.06±0.19	4066±29	0.67±0.01	0.89	0.01	0.01
3460	66100	3.84±0.49	3883±45	0.66±0.01	0.86	0.02	0.02
3511	66764	5.29±0.62	4243±36	0.57±0.02	0.82	0.02	0.02
3522	66916	3.87±0.43	3893±44	0.74±0.01	0.92	0.02	0.02
3538	67125	0.7±0.24	3105±26	0.82±0.01	0.92	0.01	0.01
3558	67391	1.22±0.21	3201±26	0.82±0.01	0.93	0.01	0.01
3567	67520	1.71±0.27	3361±28	0.77±0.01	0.90	0.01	0.01

3587	67794	3.17±0.29	3874±32	0.7±0.01	0.88	0.01	0.01
3595	67905	3.98±0.21	4248±29	0.62±0.01	0.86	0.01	0.01
3604	68028	-0.05±0.17	3185±24	0.79±0.01	0.90	0.01	0.01
3616	68194	3.92±0.22	4227±29	0.63±0.01	0.86	0.01	0.01
3675	69007	3.01±0.21	3852±27	0.69±0.01	0.87	0.01	0.01
3685	69145	1±0.26	3667±28	0.67±0.01	0.84	0.01	0.01
3705	69417	2.18±0.22	3710±24	0.69±0.01	0.86	0.01	0.01
3725	69697	4.23±0.2	3932±26	0.72±0.01	0.90	0.01	0.01
3754	70098	3.9±0.2	3988±31	0.69±0.01	0.88	0.01	0.01
3779	70401	7.24±0.51	3763±55	0.74±0.03	0.90	0.04	0.04
3799	70623	3.68±0.28	4006±31	0.71±0.01	0.90	0.02	0.02
3819	70849	2.62±0.24	3561±27	0.76±0.01	0.90	0.01	0.01
3837	71044	1.65±0.19	3274±24	0.8±0.01	0.91	0.01	0.01
3858	71279	1.88±0.21	3192±24	0.83±0.01	0.93	0.01	0.01
3868	71393	2.83±0.39	3368±24	0.78±0.01	0.90	0.01	0.01
3894	71681	0.26±0.18	3086±23	0.82±0.01	0.91	0.01	0.01
3916	71931	3.56±0.42	3569±25	0.74±0.01	0.88	0.01	0.01
4007	72957	5.1±0.25	4134±41	0.71±0.01	0.89	0.01	0.01
4016	73060	2.66±0.17	3817±23	0.68±0.01	0.84	0.01	0.01
4027	73179	3.96±0.26	4011±23	0.67±0.01	0.86	0.01	0.01
4033	73248	4.23±0.2	3994±29	0.7±0.01	0.88	0.01	0.01
4043	73356	5.67±0.3	4907±31	0.52±0.01	0.83	0.01	0.01
4051	73444	4.04±0.28	4088±23	0.62±0.01	0.82	0.01	0.01
4063	73581	6.13±0.47	4595±33	0.56±0.01	0.83	0.01	0.01
4077	73737	3.51±0.42	3471±49	0.8±0.02	0.91	0.03	0.03
4085	73827	5.54±0.32	4627±28	0.59±0.01	0.85	0.01	0.01
4093	73915	0.1±0.4	3095±58	0.87±0.02	0.94	0.03	0.03
4098	73970	4.65±0.24	4481±34	0.57±0.01	0.82	0.01	0.01
4105	74049	0.36±0.37	3120±55	0.85±0.02	0.93	0.03	0.03
4114	74151	2.81±0.31	3452±55	0.83±0.01	0.93	0.02	0.02
4130	74328	6.06±0.68	4201±45	0.66±0.01	0.86	0.02	0.02
4146	74503	5.04±0.42	3919±39	0.71±0.01	0.87	0.01	0.01
4165	74714	3.1±0.36	3860±25	0.66±0.01	0.83	0.01	0.01
4172	74796	5.27±0.21	4763±25	0.59±0.01	0.85	0.01	0.01
4192	75018	1.55±0.34	3876±30	0.63±0.01	0.80	0.01	0.01
4213	75239	4.33±0.35	4207±30	0.57±0.01	0.79	0.01	0.01
4223	75345	3.42±0.29	3991±28	0.65±0.01	0.83	0.01	0.01
4246	75588	8.87±0.91	5419±63	0.41±0.04	0.81	0.03	0.03
4267	75805	3.3±0.27	4622±38	0.48±0.01	0.77	0.01	0.01
4287	76022	5.82±0.61	4896±41	0.45±0.02	0.78	0.02	0.02
4321	76389	3.45±0.33	4174±30	0.59±0.01	0.80	0.01	0.01
4331	76495	2.45±0.33	3615±24	0.68±0.01	0.81	0.02	0.02
4424	77497	5.38±0.36	4421±26	0.59±0.01	0.82	0.01	0.01
4444	77713	5.31±0.3	4762±38	0.53±0.01	0.81	0.01	0.01
4466	77951	3.25±0.25	3734±25	0.7±0.01	0.84	0.01	0.01
4484	78145	5±0.51	4343±34	0.59±0.01	0.81	0.01	0.01



4514	78469	3.36±0.24	3629±19	0.74±0.01	0.86	0.01	0.01
4529	78625	1.45±0.35	3483±42	0.8±0.01	0.90	0.02	0.02
4539	78728	2.31±0.41	3591±41	0.77±0.01	0.88	0.02	0.02
4612	79502	4.62±0.56	4283±37	0.54±0.02	0.77	0.02	0.02
4632	79708	3.83±0.23	4278±31	0.58±0.01	0.80	0.01	0.01
4652	79926	5.86±0.58	4642±37	0.49±0.02	0.77	0.02	0.02
4726	80714	6.35±0.23	4799±25	0.59±0.01	0.84	0.01	0.01
4765	81138	7.17±0.32	5584±49	0.47±0.01	0.84	0.01	0.01
4785	81359	7.95±0.63	4907±50	0.51±0.03	0.80	0.02	0.02
4809	81623	4.62±0.3	3807±43	0.72±0.01	0.86	0.01	0.01
4828	81835	1.49±0.21	3376±22	0.76±0.01	0.85	0.01	0.01
4924	82894	3.47±0.28	3859±23	0.68±0.01	0.83	0.01	0.01
5004	83776	4.92±0.21	4393±29	0.67±0.01	0.87	0.01	0.01
5063	84991	4.02±0.33	3701±39	0.72±0.01	0.85	0.02	0.02
5120	86231	6.24±0.29	4541±40	0.61±0.01	0.83	0.01	0.01
5161	87106	2.92±0.19	3911±23	0.67±0.01	0.82	0.01	0.01
5198	87895	6.63±0.44	4290±35	0.62±0.02	0.82	0.02	0.02
5430	93809	3.74±0.34	3800±29	0.69±0.01	0.83	0.02	0.02
5473	94979	5.16±0.41	3817±40	0.74±0.02	0.87	0.03	0.03
5500	95717	4.26±0.28	3869±38	0.72±0.01	0.86	0.01	0.01
5518	96188	3.84±0.29	4049±49	0.69±0.01	0.84	0.01	0.01
5586	98028	-2.49±0.21	2164±21	0.97±0.01	0.93	0.02	0.02
5611	98710	3.85±0.2	4046±32	0.67±0.01	0.83	0.01	0.01
5657	99963	3.44±0.23	4066±26	0.63±0.01	0.79	0.01	0.01
5675	100449	3.22±0.19	4088±24	0.65±0.01	0.82	0.01	0.01
5692	100905	4.41±0.27	4154±23	0.63±0.01	0.80	0.01	0.01
5724	101774	5.83±0.32	4850±32	0.5±0.01	0.78	0.01	0.01
5741	102241	2.44±0.25	4251±27	0.58±0.01	0.77	0.01	0.01
5750	102482	3.67±0.23	4442±30	0.55±0.01	0.77	0.01	0.01
5768	102963	5.67±0.34	4451±29	0.6±0.01	0.80	0.01	0.01
5871	105756	5.25±0.47	4918±43	0.48±0.01	0.76	0.01	0.01
5936	107516	3.5±0.17	4078±27	0.65±0.01	0.79	0.01	0.01
5951	107923	5.02±0.25	4032±24	0.69±0.01	0.82	0.01	0.01
5979	108683	5.59±0.33	4276±23	0.64±0.01	0.79	0.01	0.01
6020	109722	3.79±0.34	3707±23	0.72±0.01	0.80	0.01	0.01
6035	110046	4.79±0.5	4398±35	0.57±0.01	0.74	0.01	0.01
6051	110411	5.02±0.51	4563±33	0.55±0.01	0.75	0.01	0.01
6066	110749	6.33±0.78	4625±47	0.53±0.02	0.74	0.02	0.02
6096	111418	3.5±0.33	3874±32	0.69±0.01	0.79	0.01	0.01
6126	112079	4.26±0.52	4323±36	0.66±0.02	0.80	0.02	0.02
6143	112459	2.27±0.22	3557±28	0.77±0.01	0.82	0.01	0.01
6175	113175	5±0.42	4107±32	0.62±0.02	0.74	0.02	0.02
6190	113513	3.82±0.21	4049±22	0.68±0.01	0.78	0.01	0.01
6206	113867	4.18±0.22	4009±23	0.66±0.01	0.76	0.01	0.01
6230	114397	6.93±0.41	4022±26	0.71±0.01	0.81	0.01	0.01
6260	115063	5.99±0.36	4882±33	0.49±0.01	0.73	0.01	0.01

6296	115781	5.14±0.66	4105±42	0.68±0.01	0.79	0.02	0.02
6312	116113	1.97±0.37	3255±28	0.81±0.01	0.83	0.02	0.02
6342	116716	5.95±0.38	4051±38	0.69±0.01	0.80	0.01	0.01
6380	117485	3.74±0.32	4283±32	0.59±0.01	0.73	0.01	0.01
6419	118272	7.04±0.25	4496±31	0.58±0.01	0.75	0.01	0.01
6443	118761	3.51±0.29	4299±30	0.58±0.01	0.73	0.01	0.01
6482	119547	4.14±0.17	3701±20	0.74±0.01	0.80	0.01	0.01
6515	120191	4.65±0.35	4561±39	0.52±0.01	0.71	0.01	0.01
6553	120787	5.66±0.3	4795±32	0.53±0.01	0.74	0.01	0.01
6606	121607	4.14±0.28	4252±27	0.62±0.01	0.76	0.01	0.01
6649	122274	6.35±0.3	4906±33	0.54±0.01	0.76	0.01	0.01
6675	122671	5.71±0.42	4259±42	0.65±0.01	0.78	0.02	0.02
6693	122943	5.59±0.4	4627±36	0.5±0.01	0.71	0.01	0.01
6711	123214	5.12±0.45	4379±33	0.59±0.01	0.75	0.01	0.01
6721	123364	6.38±0.47	4577±38	0.59±0.01	0.77	0.01	0.01
6735	123573	4±0.35	4815±41	0.44±0.01	0.70	0.01	0.01
6827	124849	5.9±0.37	4721±34	0.54±0.01	0.75	0.01	0.01
6847	125110	9.14±1.17	4924±68	0.45±0.05	0.72	0.04	0.04
6854	125206	6.24±0.41	4577±40	0.54±0.02	0.74	0.02	0.02
6874	125476	10.99±1.75	4961±97	0.4±0.07	0.69	0.06	0.05
6897	125786	3.74±0.23	4358±37	0.57±0.01	0.74	0.01	0.01
6911	125976	5.27±0.26	4331±35	0.64±0.01	0.79	0.01	0.01
6912	125989	8.75±1.23	5028±71	0.45±0.05	0.73	0.04	0.04
6923	126137	7.21±1.23	4210±56	0.53±0.05	0.70	0.05	0.04
6935	126304	8.01±1.06	4543±54	0.52±0.04	0.73	0.04	0.04
6942	126391	5.89±0.66	4187±38	0.59±0.02	0.74	0.03	0.03
6946	126449	4.07±0.31	4276±31	0.63±0.01	0.78	0.01	0.01
6961	126654	4.09±0.45	4019±31	0.62±0.02	0.75	0.02	0.02
6964	126690	5.99±0.67	4453±43	0.53±0.02	0.73	0.02	0.02
6968	126747	5.58±0.68	4511±38	0.53±0.03	0.73	0.02	0.02
6982	126937	3.98±0.22	4405±26	0.55±0.01	0.73	0.01	0.01
6985	126980	5.95±0.61	4381±35	0.56±0.01	0.74	0.01	0.01
6991	127060	6.39±0.49	5114±53	0.46±0.02	0.75	0.02	0.01
7006	127265	6.14±0.44	5507±64	0.42±0.02	0.76	0.01	0.01
7021	127458	4.86±0.4	5044±55	0.47±0.02	0.75	0.01	0.01
7025	127505	6.01±0.62	5007±50	0.45±0.02	0.73	0.02	0.02
7028	127542	6.61±0.68	5334±56	0.41±0.02	0.74	0.02	0.02
7029	127553	10.93±1.63	5338±91	0.37±0.07	0.73	0.05	0.04
7039	127678	6.34±0.23	4615±31	0.6±0.01	0.79	0.01	0.01
7050	127814	5.73±0.27	4750±32	0.57±0.01	0.78	0.01	0.01
7067	128021	3.98±0.25	4199±31	0.57±0.01	0.73	0.01	0.01
7071	128072	5.72±0.36	4320±31	0.62±0.01	0.78	0.01	0.01
7075	128118	4.34±0.27	3962±35	0.67±0.01	0.79	0.01	0.01
7082	128204	3.92±0.25	3966±36	0.69±0.01	0.80	0.01	0.01
7086	128254	4.85±0.18	4648±32	0.56±0.01	0.77	0.01	0.01
7093	128341	4.81±0.34	4779±44	0.54±0.01	0.77	0.01	0.01

7097	128392	6.61±0.47	5543±65	0.42±0.02	0.77	0.01	0.01
7132	128828	5.74±0.42	4686±31	0.53±0.01	0.75	0.01	0.01
7142	128950	5.62±0.33	4683±32	0.53±0.01	0.75	0.01	0.01
7147	129007	3.02±0.25	4435±37	0.58±0.01	0.77	0.01	0.01
7152	129070	6.11±0.37	4580±37	0.54±0.02	0.75	0.02	0.02
7163	129203	6.72±0.55	4518±32	0.62±0.01	0.80	0.02	0.02
7173	129329	2.13±0.25	4188±34	0.63±0.01	0.78	0.01	0.01
7178	129389	4.62±0.21	4121±28	0.67±0.01	0.81	0.01	0.01
7185	129476	4.85±0.3	4037±29	0.68±0.01	0.81	0.02	0.01
7189	129527	4.17±0.15	3827±26	0.72±0.01	0.82	0.01	0.01
7214	129828	4.94±0.38	4325±29	0.6±0.01	0.77	0.01	0.01
7224	129954	3.72±0.24	3636±25	0.72±0.01	0.81	0.01	0.01
7234	130075	5.37±0.46	3983±27	0.65±0.02	0.78	0.02	0.02
7245	130212	6.38±0.34	4352±38	0.63±0.01	0.80	0.02	0.02
7259	130382	4.24±0.24	4128±27	0.64±0.01	0.79	0.01	0.01
7264	130454	6.21±0.34	4404±31	0.6±0.01	0.78	0.01	0.01
7295	130909	5.26±0.2	4403±28	0.62±0.01	0.80	0.01	0.01
7304	131044	5.93±0.48	4251±31	0.61±0.01	0.78	0.01	0.01
7309	131119	5.15±0.34	4000±35	0.68±0.01	0.81	0.02	0.01
7314	131192	3.14±0.21	3875±27	0.67±0.01	0.79	0.01	0.01
7319	131271	6.82±0.25	4714±27	0.58±0.01	0.80	0.01	0.01

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SI Table 4: Reconstructed average values of mean temperature of the coldest month (MTCO, °C), growing degree days above a base level of 0° C (GDD<sub>0</sub>) and moisture index (the ratio of annual precipitation to annual potential evapotranspiration, MI) for Marine Isotope Stages (MIS) and substages, calculated from the interpolated yearly values of each variable. The transitional phase at the beginning of MIS 5 corresponding to the Zeifen-Kattegat Oscillation is labelled Zeifen in the column showing the Marine Isotopic Stages.

	MTCO	GDD0	MI
MIS 1	4.74	4016	0.64
MIS 2	0.82	3549	0.87
MIS 3	2.21	4276	0.71
MIS 4	3.17	3779	0.81
MIS 5a	4.29	4116	0.71
MIS 5b	4.71	4154	0.68
MIS 5c	3.96	4106	0.67
MIS 5d	4.57	4185	0.6
MIS 5e	5.13	4384	0.57
Zeifen	5.43	4339	0.6
MIS 6	5.62	4324	0.63