Lago di Fimon Data: MI and Pann corrections

(45.469951, 11.543468)

Obtain past CO2 from (Bereiter et al. 2015)

```
past_co2 <- fimon %>%
  .$age_cal_yr_BP %>%
  purrr::map_dbl(codos::past_co2)
```

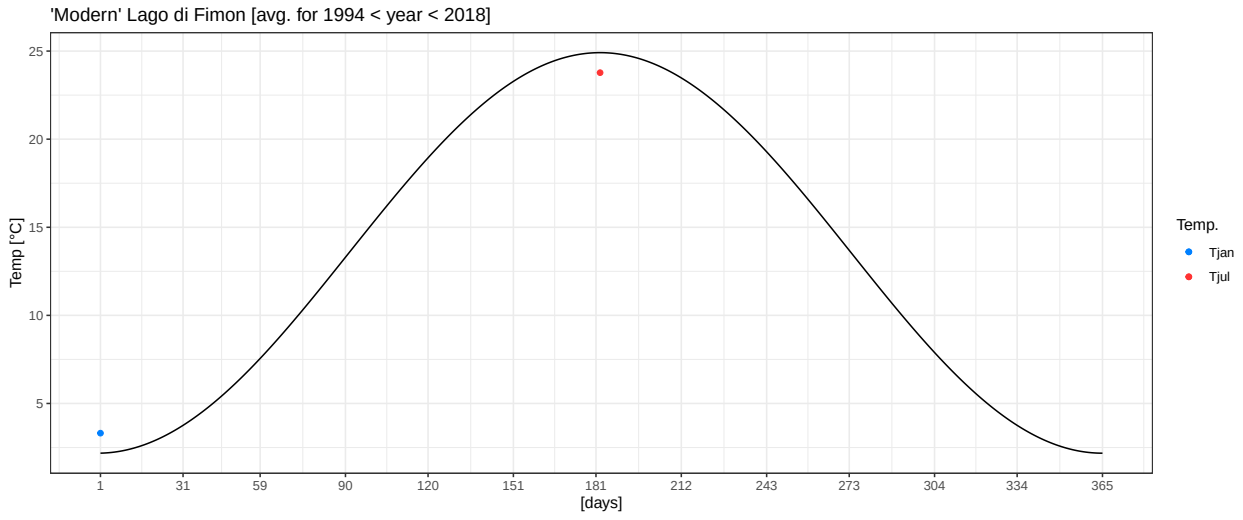
Obtain modern CO2 from (Bereiter et al. 2015)

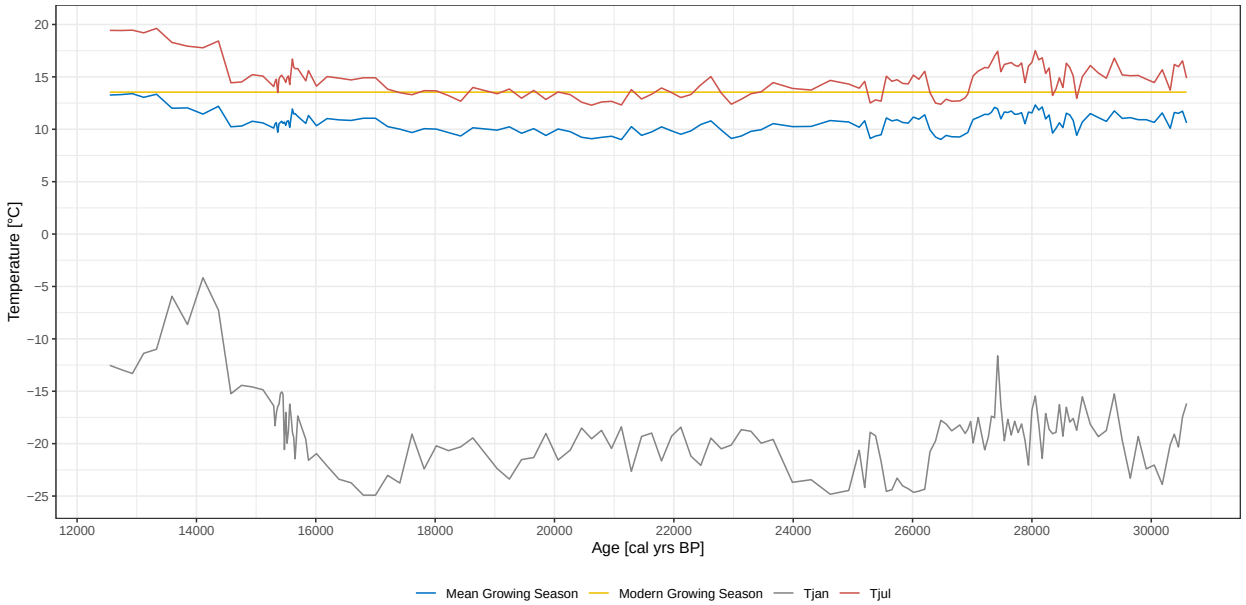
```
modern_co2 <- tibble::tibble(age = 1950 - c(1901:1990),
                             co2 = purrr::map_dbl(age, codos::past_co2)) %>%
  .$co2 %>%
  median()
```

Read "modern" data - Quinto Vicentino

```
quinto_vicentino_tmin <- readr::read_csv("/path/to/fimon-lake/quinto_vicentino_tmin.csv",
                                         na = ">>") %>%
  magrittr::set_names(tolower(colnames(.)))
quinto_vicentino_tmax <- readr::read_csv("/path/to/fimon-lake/quinto_vicentino_tmax.csv",
                                         na = ">>") %>%
  magrittr::set_names(tolower(colnames(.)))
```

Fit a sinusoidal curve between the mean value for the coldest month, `T_jan = 3.3146`, and the warmest month, `T_jul = 23.7739`.





Assemble the *Lago di Fimon* data

```
fimon2 <- tibble::tibble(age_calBP = fimon$age_cal_yr_BP,
                         past_temp = fimon$Tgs,
                         past_co2 = past_co2,
                         modern_co2 = modern_co2,
                         present_t = mean(quinto_vicentino_tmp),
                         recon_mi = fimon$MI,
                         recon_Pann = fimon$Pann)
```

Find the corrected `MI`

```
fimon2$corr_mi <- codos::corrected_mi(fimon2$present_t,
                                      fimon2$past_temp,
                                      fimon2$recon_mi,
                                      fimon2$modern_co2,
                                      fimon2$past_co2)
```

age cal yr BP	past temp	past co2	modern co2	present temp	recon. MI	recon. Pann	corr. MI
12548	13.26622	247.095	311.765	13.54425	0.6104173	580.6471	0.7342405
12737	13.31012	244.445	311.765	13.54425	0.5603200	531.1387	0.6936090
12927	13.39837	238.485	311.765	13.54425	0.7353834	671.8961	0.8925061
13116	13.04907	238.190	311.765	13.54425	0.7079373	663.4637	0.8439122
13331	13.34318	236.860	311.765	13.54425	0.7216559	658.5455	0.8799385
13590	12.00859	243.860	311.765	13.54425	0.7688588	650.2817	0.8246798
13850	12.04009	238.515	311.765	13.54425	0.7732308	627.7127	0.8457674

Find the corrected Annual Precipitation, `Pann`

Approximated as the ratio

$$\mathrm{MI}_{\mathrm{ratio}} = \frac{\text{corrected}}{\text{reconstructed}}$$

multiplied by reconstructed `Pann`.

age cal yr BP	past temp	past co2	modern co2	present temp	recon. MI	corr. MI	recon. Pann	corr. Pann
12548	13.266217	247.095	311.765	13.54425	0.6104173	580.6471	0.7342405	698.4314
12737	13.310121	244.445	311.765	13.54425	0.5603200	531.1387	0.6936090	657.4860
12927	13.398367	238.485	311.765	13.54425	0.7353834	671.8961	0.8925061	815.4541
13116	13.049074	238.190	311.765	13.54425	0.7079373	663.4637	0.8439122	790.8965
13331	13.343179	236.860	311.765	13.54425	0.7216559	658.5455	0.8799385	802.9859
13590	12.008586	243.860	311.765	13.54425	0.7688588	650.2817	0.8246798	697.4937
13850	12.040088	238.515	311.765	13.54425	0.7732308	627.7127	0.8457674	686.5983
14109	11.449482	234.640	311.765	13.54425	0.7948950	649.0931	0.8417454	687.3501
14369	12.195733	239.360	311.765	13.54425	0.7913471	639.3712	0.8710726	703.7856
14578	10.239288	238.870	311.765	13.54425	0.5087981	404.7196	0.4769689	379.4013
14757	10.307509	227.900	311.765	13.54425	0.4701792	381.7680	0.4736902	384.6188
14936	10.765795	228.680	311.765	13.54425	0.4698498	386.1915	0.4976559	409.0466
15115	10.603367	232.070	311.765	13.54425	0.4666316	379.1291	0.4753819	386.2386
15295	10.113954	226.705	311.765	13.54425	0.4651172	373.2063	0.4610480	369.9412
15317	10.510248	227.640	311.765	13.54425	0.5454642	415.9699	0.5599306	427.0019
15339	10.636228	228.280	311.765	13.54425	0.4719894	365.1981	0.4933968	381.7619
15362	9.718953	227.155	311.765	13.54425	0.4419405	335.6987	0.4145272	314.8755
15384	10.539899	225.065	311.765	13.54425	0.4556153	360.9716	0.4812180	381.2559
15407	10.654296	225.065	311.765	13.54425	0.4382268	356.2088	0.4707850	382.6734
15429	10.767674	224.005	311.765	13.54425	0.4567170	370.4210	0.4987160	404.4843

Check out and download the entire dataset in Appendix A1.

New corrections

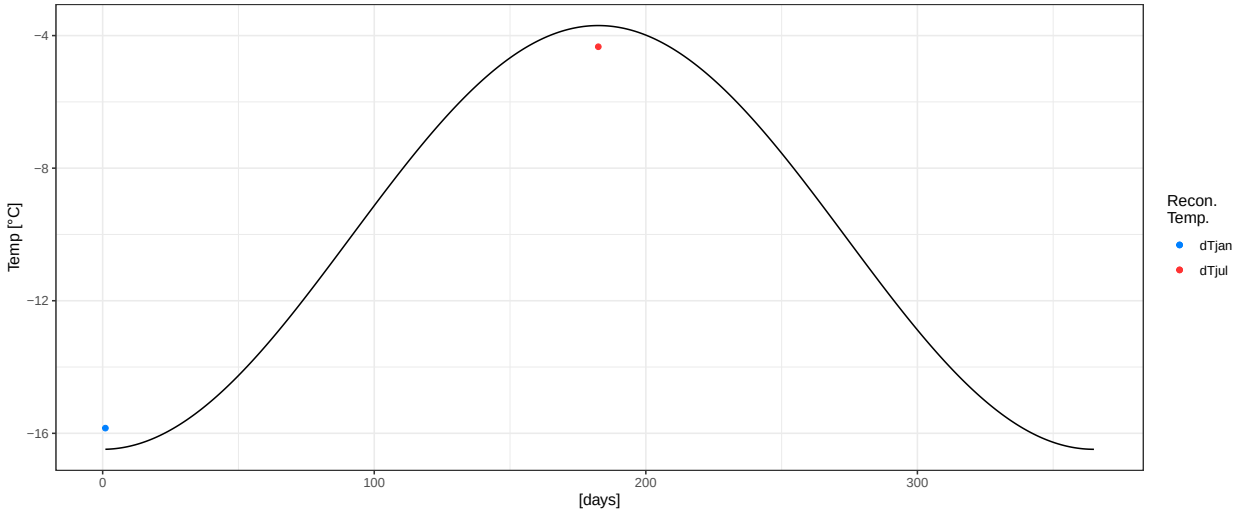
Find anomalies (`Tmp` and `cld`)

Data from the weather station Quinto Vicentino was used as the baseline to calculate the temperature anomalies.

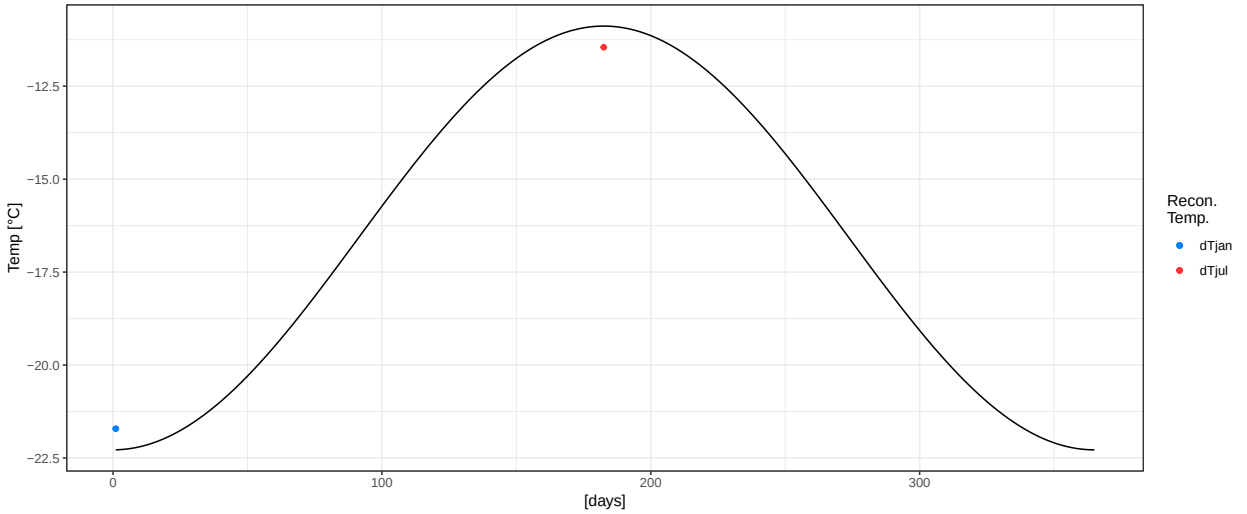
```
fimon_tmp_anomalies <- seq_len(nrow(fimon)) %>%
  purrr::map(~codos::int_sin(fimon$Tmin[.x] - fimon_modern$Tmin,
                             fimon$Tmax[.x] - fimon_modern$Tmax))

fimon_cld_anomalies <- seq_len(nrow(fimon)) %>%
  purrr::map_dbl(~fimon_cld_corr_mi[.x] - ref_cld_corr_mi)
fimon_sf_anomalies <- 1 - (fimon_cld_corr_mi + fimon_cld_anomalies) / 100
```

Lago di Fimon: Anomalies for age = 12548 cal yr BP



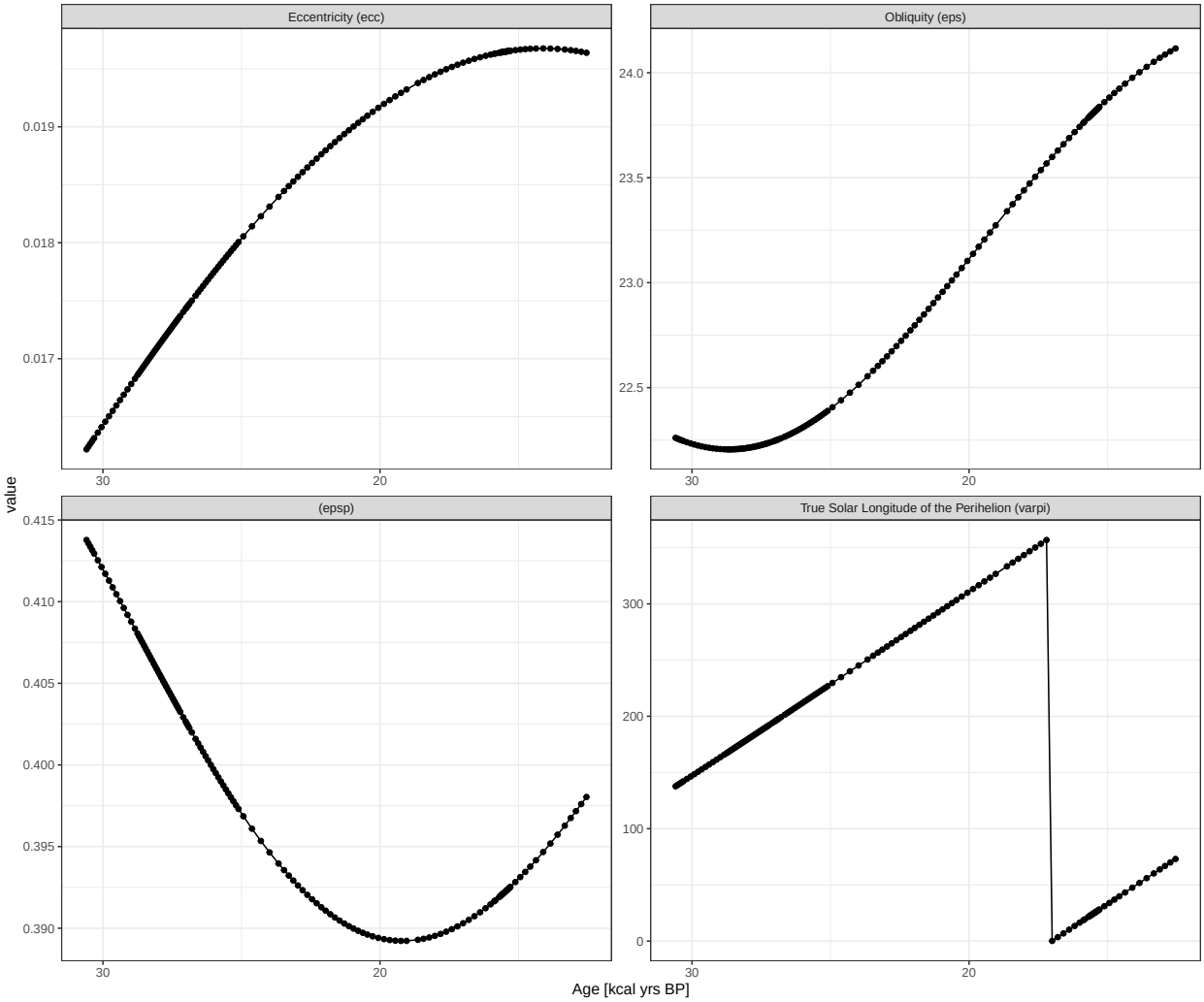
Lago di Fimon: Anomalies for age = 21121 cal yr BP



Find orbital parameters

Selected samples and their orbital parameters:

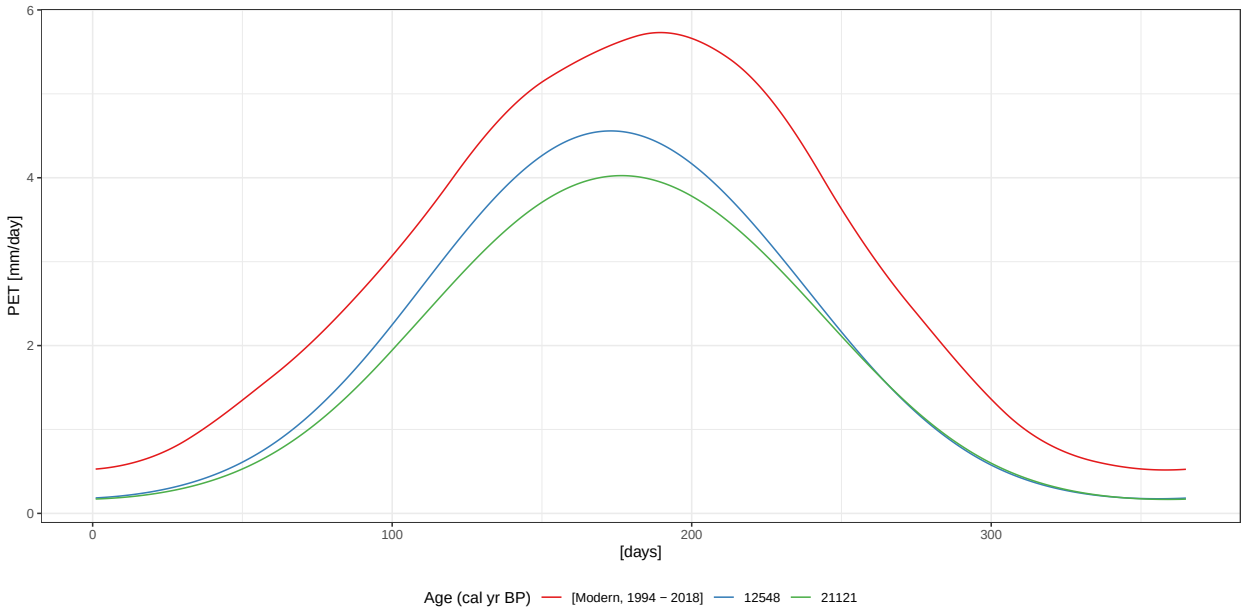
year	eps	ecc	varpi	epsp
12548	24.11564	0.0196384	73.05159	0.3980368
12737	24.10148	0.0196468	69.95812	0.3976019
12927	24.08645	0.0196542	66.84861	0.3971713
13116	24.07073	0.0196605	63.75573	0.3967500
21121	22.92946	0.0189703	292.43144	0.3901260
30592	22.26079	0.0162180	137.72150	0.4137755



Calculate potential evapotranspiration (PET)

Params (`splash::calc_daily_evap`)

- Latitude: 45.469951
- Elevation: 8
- Year: `1961`
- Sunshine fraction: [`CRU TS 4.04`] $ + `Cld`_anomalies$
- Temperature: [`CRU TS 4.04`] $ + {Tmp}_anomalies$



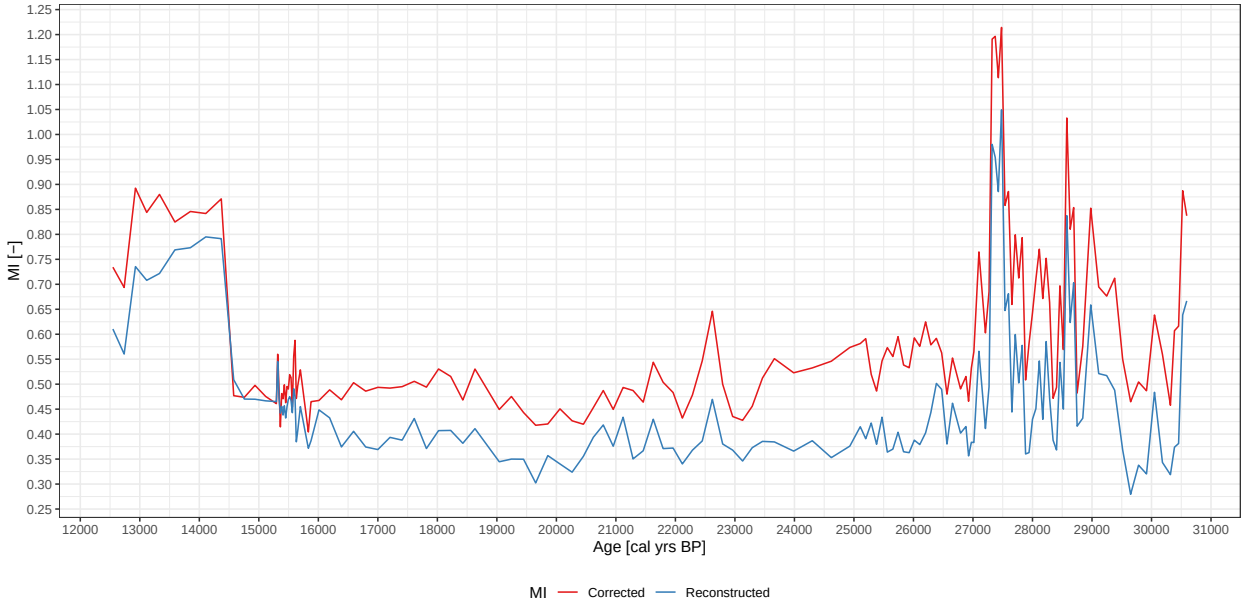
Calculate corrected Precipitation

$$\text{corrected } P_{ann} = MI \times PET_{ann}$$

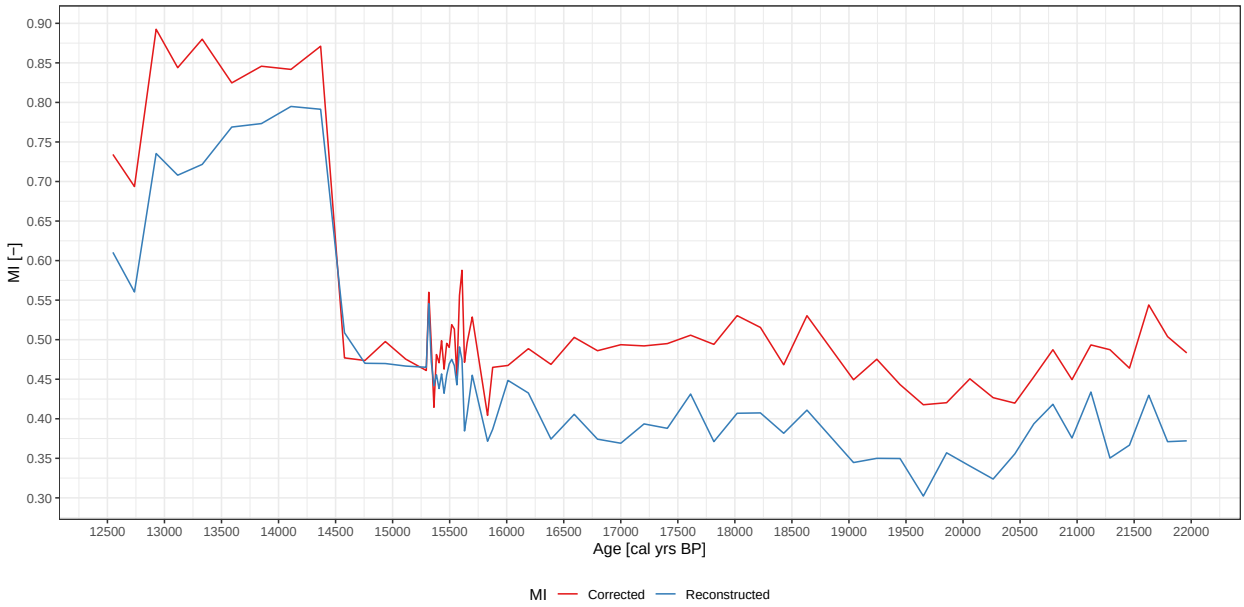
age_cal_yr_BP	MI	Pann	corr MI	corr Pann (MI ratio)	corr Pann (Tmp + Cld anomalies & Orb. Par.)
12548	0.6104173	580.6471	0.7342405	698.4314	523.9785
12737	0.5603200	531.1387	0.6936090	657.4860	503.4221
12927	0.7353834	671.8961	0.8925061	815.4541	589.4234
13116	0.7079373	663.4637	0.8439122	790.8965	574.3824
13331	0.7216559	658.5455	0.8799385	802.9859	596.2966
13590	0.7688588	650.2817	0.8246798	697.4937	580.8375
13850	0.7732308	627.7127	0.8457674	686.5983	572.8826
14109	0.7948950	649.0931	0.8417454	687.3501	590.8360
14369	0.7913471	639.3712	0.8710726	703.7856	595.3550
14578	0.5087981	404.7196	0.4769689	379.4013	345.6542
14757	0.4701792	381.7680	0.4736902	384.6188	346.8363
14936	0.4698498	386.1915	0.4976559	409.0466	363.6096

Plots

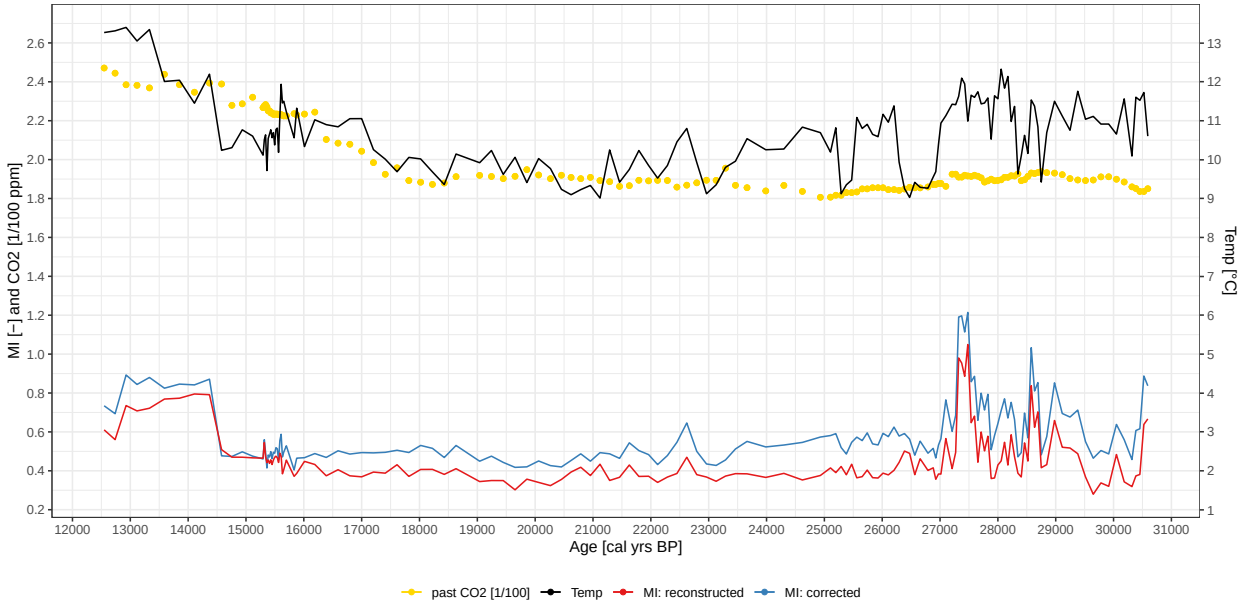
Reconstructed vs corrected MI: Past CO2 calculated using mean



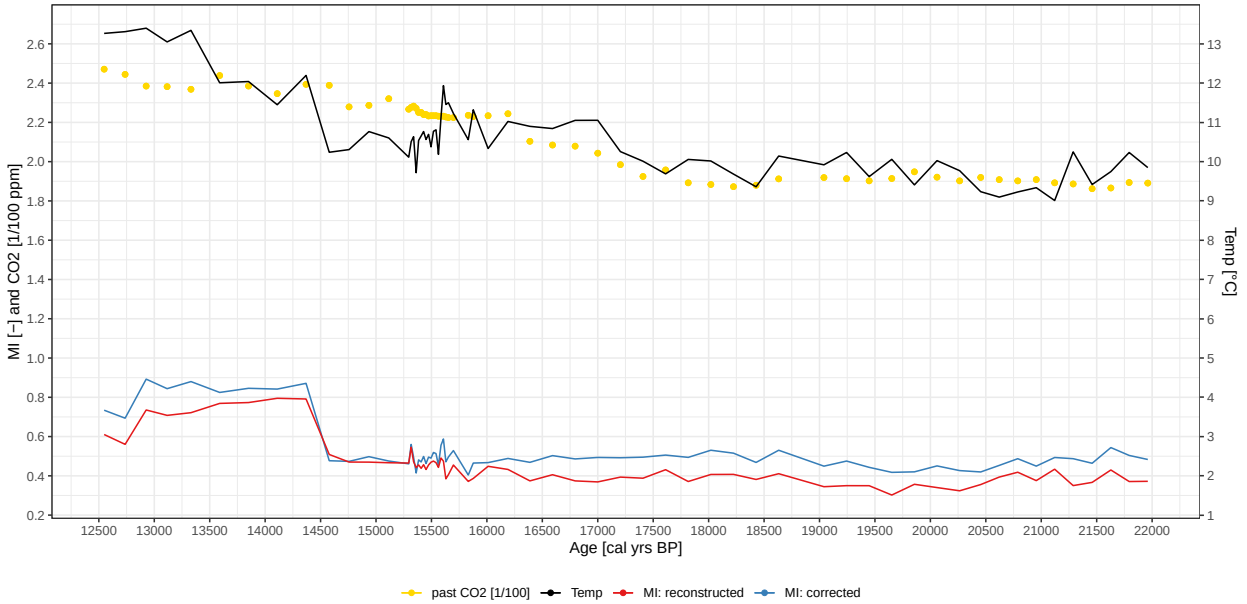
- age < 22k



Include past CO2 and Temperature

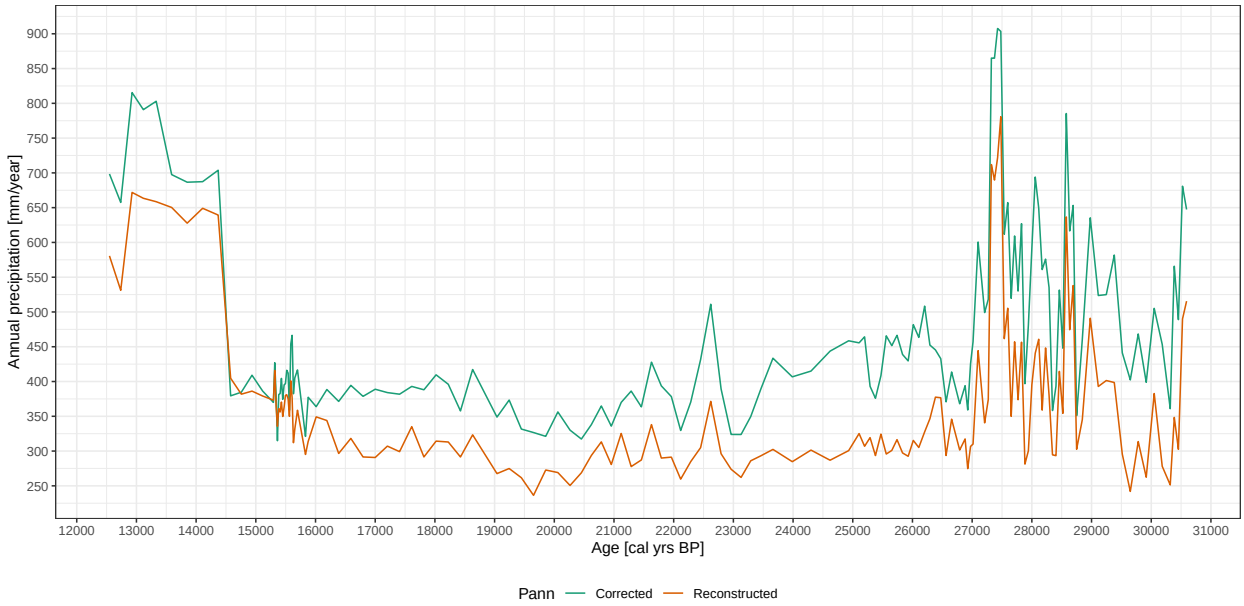


- age < 22k



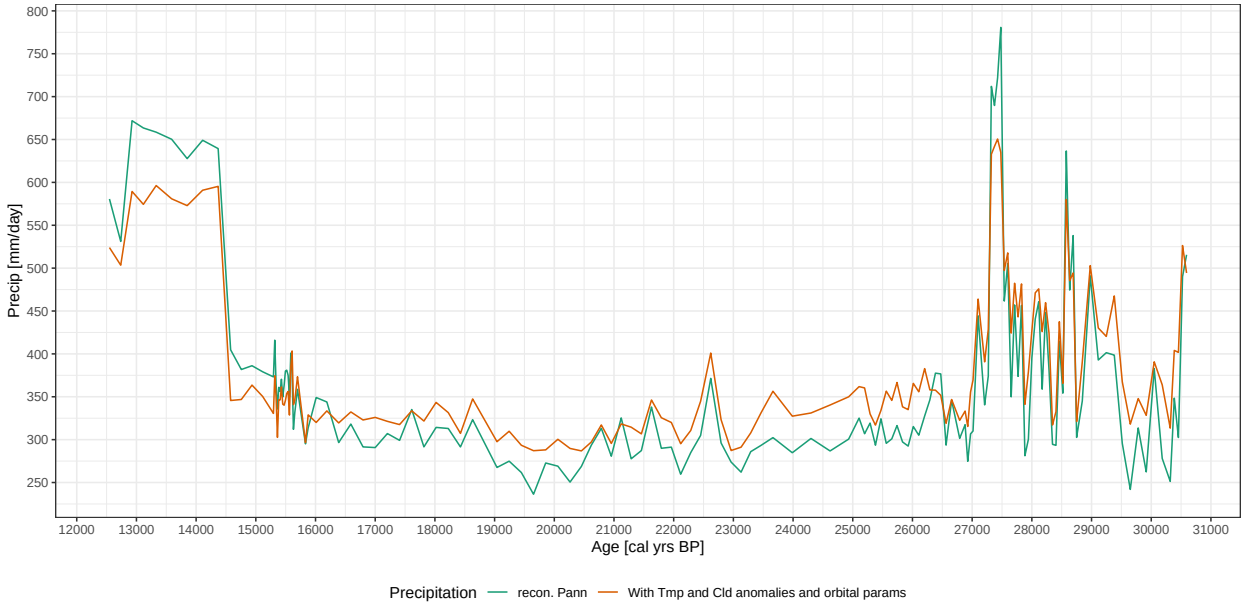
Reconstructed vs corrected Pann: Past CO2 calculated using mean

With MI ratio



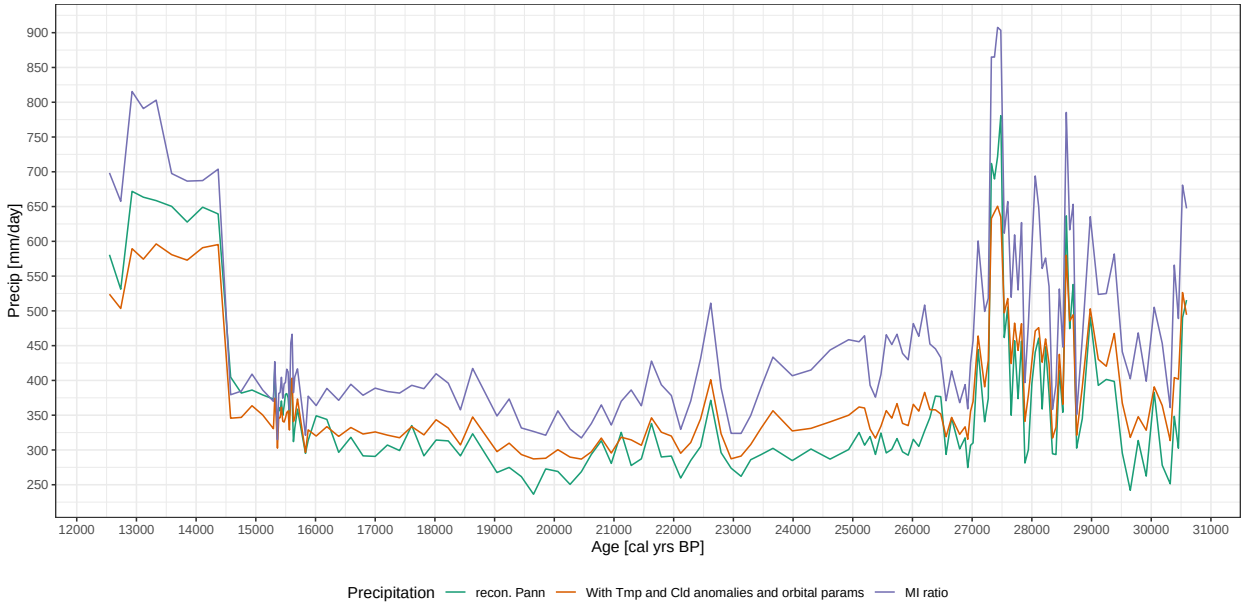
- age < 22k

With temperature and cloud coverage anomalies and orbital parameters

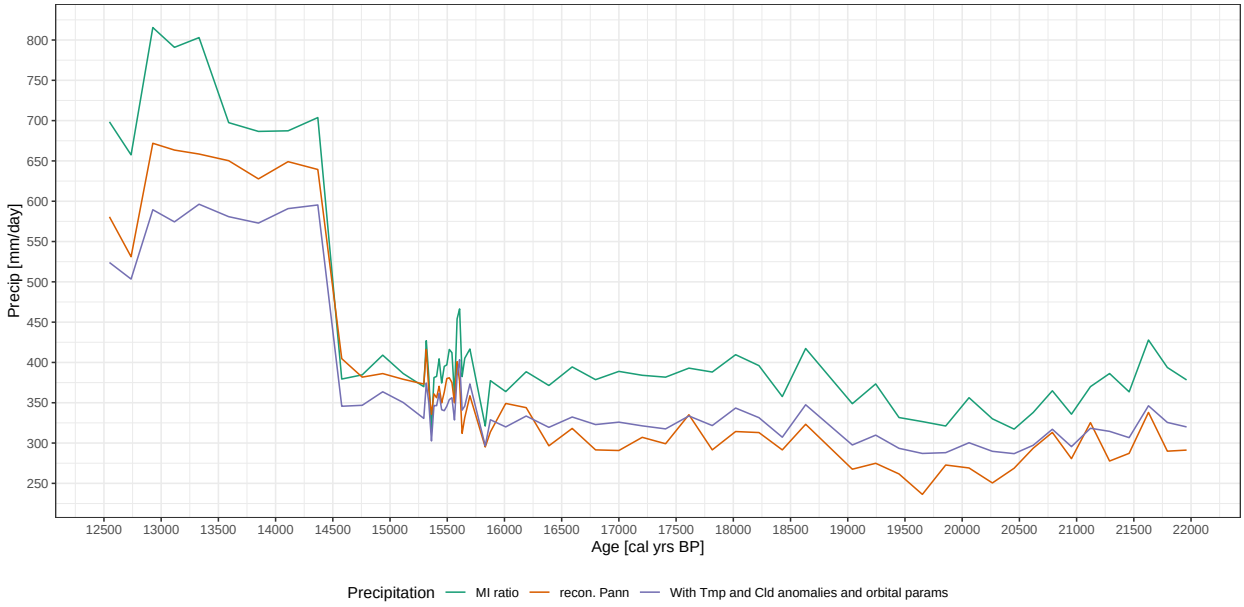


`age < 22k`

All the approaches



age < 22k



Appendix

A1. Lago di Fimon Data

Download the CSV file: fimon-with-corrected-mi.csv

age_calBP	past_temp	past_co2	modern_co2	present_t	recon_mi	recon_Pann	corr_mi	corr_Pann
12548	13.266217	247.095	311.765	13.54425	0.6104173	580.6471	0.7342405	698.4314
12737	13.310121	244.445	311.765	13.54425	0.5603200	531.1387	0.6936090	657.4860
12927	13.398367	238.485	311.765	13.54425	0.7353834	671.8961	0.8925061	815.4541
13116	13.049074	238.190	311.765	13.54425	0.7079373	663.4637	0.8439122	790.8965
13331	13.343179	236.860	311.765	13.54425	0.7216559	658.5455	0.8799385	802.9859
13590	12.008586	243.860	311.765	13.54425	0.7688588	650.2817	0.8246798	697.4937
13850	12.040088	238.515	311.765	13.54425	0.7732308	627.7127	0.8457674	686.5983
14109	11.449482	234.640	311.765	13.54425	0.7948950	649.0931	0.8417454	687.3501
14369	12.195733	239.360	311.765	13.54425	0.7913471	639.3712	0.8710726	703.7856
14578	10.239288	238.870	311.765	13.54425	0.5087981	404.7196	0.4769689	379.4013
14757	10.307509	227.900	311.765	13.54425	0.4701792	381.7680	0.4736902	384.6188
14936	10.765795	228.680	311.765	13.54425	0.4698498	386.1915	0.4976559	409.0466
15115	10.603367	232.070	311.765	13.54425	0.4666316	379.1291	0.4753819	386.2386
15295	10.113954	226.705	311.765	13.54425	0.4651172	373.2063	0.4610480	369.9412
15317	10.510248	227.640	311.765	13.54425	0.5454642	415.9699	0.5599306	427.0019
15339	10.636228	228.280	311.765	13.54425	0.4719894	365.1981	0.4933968	381.7619
15362	9.718953	227.155	311.765	13.54425	0.4419405	335.6987	0.4145272	314.8755
15384	10.539899	225.065	311.765	13.54425	0.4556153	360.9716	0.4812180	381.2559
15407	10.654296	225.065	311.765	13.54425	0.4382268	356.2088	0.4707850	382.6734
15429	10.767674	224.005	311.765	13.54425	0.4567170	370.4210	0.4987160	404.4843
15451	10.562954	224.005	311.765	13.54425	0.4322369	349.7368	0.4627942	374.4617
15474	10.695030	223.270	311.765	13.54425	0.4554099	363.2278	0.4954255	395.1436
15496	10.377678	223.400	311.765	13.54425	0.4693971	380.0470	0.4902907	396.9635
15518	10.773269	223.400	311.765	13.54425	0.4751379	380.9936	0.5189900	416.1568
15541	10.810595	223.400	311.765	13.54425	0.4672453	375.0532	0.5134085	412.1080
15563	10.185928	223.145	311.765	13.54425	0.4428890	349.9122	0.4540286	358.7132
15586	11.124733	223.145	311.765	13.54425	0.4908755	400.9151	0.5559204	454.0395
15608	11.935365	223.145	311.765	13.54425	0.4745624	376.6003	0.5877322	466.4089
15630	11.456396	222.760	311.765	13.54425	0.3846061	312.0294	0.4713694	382.4202
15653	11.500779	222.460	311.765	13.54425	0.4059562	331.6249	0.4960506	405.2229
15698	11.226957	222.460	311.765	13.54425	0.4550534	358.6714	0.5286480	416.6784

age_calBP	past_temp	past_co2	modern_co2	present_t	recon_mi	recon_Pann	corr_mi	corr_Pann
15832	10.560156	223.610	311.765	13.54425	0.3715463	295.1067	0.4042802	321.1061
15877	11.321146	222.935	311.765	13.54425	0.3866602	313.7987	0.4650201	377.3926
16011	10.335111	223.400	311.765	13.54425	0.4485396	349.1470	0.4674070	363.8336
16190	11.023666	224.405	311.765	13.54425	0.4325579	343.9236	0.4886168	388.4956
16388	10.898787	210.360	311.765	13.54425	0.3743157	296.5703	0.4687477	371.3887
16592	10.843108	208.460	311.765	13.54425	0.4056510	318.1669	0.5029202	394.4587
16796	11.051719	207.890	311.765	13.54425	0.3742106	291.5290	0.4860529	378.6598
17000	11.053536	204.320	311.765	13.54425	0.3690658	290.7584	0.4936389	388.8999
17204	10.256339	198.460	311.765	13.54425	0.3934976	307.0949	0.4921347	384.0737
17408	10.011196	192.455	311.765	13.54425	0.3879071	299.1497	0.4950338	381.7646
17612	9.688878	195.790	311.765	13.54425	0.4312829	335.1350	0.5056728	392.9408
17816	10.056964	189.230	311.765	13.54425	0.3711237	291.5426	0.4940448	388.1054
18020	10.017040	188.375	311.765	13.54425	0.4069588	314.2815	0.5303886	409.6025
18224	9.683744	187.265	311.765	13.54425	0.4074088	313.0220	0.5154561	396.0373
18428	9.360746	187.960	311.765	13.54425	0.3816363	291.5168	0.4682690	357.6921
18632	10.143186	191.235	311.765	13.54425	0.4109214	323.3310	0.5303244	417.2826
19040	9.919833	191.900	311.765	13.54425	0.3446474	267.5633	0.4493288	348.8315
19244	10.234145	191.335	311.765	13.54425	0.3499654	274.9005	0.4752935	373.3467
19448	9.619730	190.235	311.765	13.54425	0.3497317	261.6832	0.4432444	331.6532
19652	10.059559	191.420	311.765	13.54425	0.3022315	236.3271	0.4177130	326.6268
19856	9.409042	194.830	311.765	13.54425	0.3569768	272.7675	0.4203086	321.1596
20060	10.026597	192.095	311.765	13.54425	0.3402560	269.0825	0.4505216	356.2832
20264	9.770067	190.230	311.765	13.54425	0.3238047	250.5088	0.4266693	330.0891
20454	9.235206	191.960	311.765	13.54425	0.3555843	268.7711	0.4197606	317.2793
20621	9.097524	190.845	311.765	13.54425	0.3936621	293.6537	0.4530966	337.9891
20788	9.228258	190.210	311.765	13.54425	0.4183326	313.2123	0.4872958	364.8461
20955	9.336702	190.870	311.765	13.54425	0.3756592	280.6580	0.4494878	335.8159
21121	9.010375	189.225	311.765	13.54425	0.4338236	325.3255	0.4933797	369.9868
21288	10.248790	188.645	311.765	13.54425	0.3503193	277.6850	0.4873017	386.2658
21459	9.417773	186.235	311.765	13.54425	0.3666595	287.2509	0.4639955	363.5065
21628	9.747203	186.595	311.765	13.54425	0.4297748	338.0219	0.5439386	427.8128
21793	10.233587	189.370	311.765	13.54425	0.3710240	289.9326	0.5038784	393.7502
21961	9.849288	189.080	311.765	13.54425	0.3720975	291.2695	0.4832948	378.3122
22117	9.524081	189.325	311.765	13.54425	0.3403084	259.6103	0.4320232	329.5765

age_calBP	past_temp	past_co2	modern_co2	present_t	recon_mi	recon_Pann	corr_mi	corr_Pann
22286	9.847777	189.245	311.765	13.54425	0.3678182	284.8942	0.4783421	370.5007
22451	10.455059	185.850	311.765	13.54425	0.3863056	304.9136	0.5467457	431.5501
22621	10.801068	186.850	311.765	13.54425	0.4695378	371.4407	0.6460814	511.1003
22794	9.925817	188.070	311.765	13.54425	0.3802290	296.1362	0.4999055	389.3446
22962	9.123159	189.400	311.765	13.54425	0.3679825	273.8504	0.4352679	323.9238
23129	9.352415	189.340	311.765	13.54425	0.3461524	262.1023	0.4276317	323.7974
23291	9.801209	195.600	311.765	13.54425	0.3728354	285.9903	0.4558016	349.6311
23463	9.959096	186.780	311.765	13.54425	0.3854142	293.2969	0.5122686	389.8320
23663	10.538265	185.560	311.765	13.54425	0.3843895	302.3884	0.5510851	433.5231
23987	10.253437	183.905	311.765	13.54425	0.3659864	284.7319	0.5227800	406.7150
24300	10.272106	186.730	311.765	13.54425	0.3867717	301.3982	0.5325339	414.9858
24620	10.835434	183.650	311.765	13.54425	0.3529370	286.8193	0.5459690	443.6895
24931	10.693080	180.630	311.765	13.54425	0.3759896	300.6213	0.5735241	458.5594
25106	10.192470	180.690	311.765	13.54425	0.4148334	325.1340	0.5813092	455.6128
25198	10.817728	181.675	311.765	13.54425	0.3907004	306.8630	0.5911076	464.2664
25290	9.121652	181.675	311.765	13.54425	0.4221757	319.3260	0.5196829	393.0787
25380	9.352006	183.020	311.765	13.54425	0.3796770	293.5128	0.4861884	375.8524
25472	9.473377	183.020	311.765	13.54425	0.4338403	324.3084	0.5464453	408.4839
25561	11.083272	183.380	311.765	13.54425	0.3639550	295.7344	0.5731359	465.7059
25654	10.801333	184.960	311.765	13.54425	0.3700087	300.9135	0.5552463	451.5599
25741	10.906940	184.960	311.765	13.54425	0.4037598	316.4436	0.5952171	466.4967
25834	10.649276	185.530	311.765	13.54425	0.3646720	297.2957	0.5383534	438.8880
25928	10.588668	185.530	311.765	13.54425	0.3628614	292.4988	0.5329136	429.5761
26014	11.165762	185.530	311.765	13.54425	0.3878914	315.2895	0.5927265	481.7855
26106	10.960727	184.545	311.765	13.54425	0.3790444	305.1368	0.5756728	463.4258
26204	11.381895	184.570	311.765	13.54425	0.4025573	327.5677	0.6247553	508.3739
26292	9.936640	184.170	311.765	13.54425	0.4431722	346.4735	0.5786691	452.4054
26385	9.257054	184.890	311.765	13.54425	0.5014990	377.5408	0.5916827	445.4333
26474	9.027001	185.760	311.765	13.54425	0.4896647	376.6521	0.5626716	432.8093
26563	9.415805	185.510	311.765	13.54425	0.3801492	293.6164	0.4800468	370.7745
26656	9.288182	185.475	311.765	13.54425	0.4618198	345.8594	0.5523869	413.6856
26791	9.263657	185.935	311.765	13.54425	0.4019588	301.4909	0.4905895	367.9687
26882	9.552970	187.255	311.765	13.54425	0.4152275	317.4304	0.5153621	393.9807
26926	9.689455	187.255	311.765	13.54425	0.3564121	274.7229	0.4658377	359.0683

age_calBP	past_temp	past_co2	modern_co2	present_t	recon_mi	recon_Pann	corr_mi	corr_Pann
26973	10.389917	187.735	311.765	13.54425	0.3836743	306.6781	0.5323769	425.5389
27015	10.936895	187.735	311.765	13.54425	0.3831848	310.0836	0.5648133	457.0623
27100	11.129036	186.270	311.765	13.54425	0.5658541	444.3265	0.7647902	600.5374
27209	11.424672	192.495	311.765	13.54425	0.4112296	340.5462	0.6027686	499.1629
27270	11.411419	192.495	311.765	13.54425	0.4946910	374.1085	0.6853063	518.2607
27322	11.626774	191.005	311.765	13.54425	0.9801671	711.9451	1.1909620	865.0561
27374	12.094544	191.005	311.765	13.54425	0.9541025	689.6757	1.1964967	864.8911
27426	11.947412	191.950	311.765	13.54425	0.8856040	721.7586	1.1136261	907.5944
27480	10.988989	191.590	311.765	13.54425	1.0492718	780.7094	1.2142380	903.4523
27538	11.655281	191.380	311.765	13.54425	0.6474583	461.6283	0.8580021	611.7430
27596	11.600494	191.950	311.765	13.54425	0.6810894	505.3575	0.8857966	657.2470
27654	11.745321	191.460	311.765	13.54425	0.4442326	349.9552	0.6596326	519.6419
27711	11.432715	190.610	311.765	13.54425	0.5994570	457.0705	0.7990589	609.2618
27769	11.454023	188.445	311.765	13.54425	0.5024990	373.8128	0.7125531	530.0736
27827	11.585765	189.085	311.765	13.54425	0.5776934	456.5127	0.7933689	626.9467
27884	10.525778	189.930	311.765	13.54425	0.3602705	281.2339	0.5083940	396.8619
27942	11.641609	189.140	311.765	13.54425	0.3630040	300.4253	0.5814915	481.2475
28000	11.563750	189.290	311.765	13.54425	0.4296742	395.2297	0.6428969	591.3596
28057	12.324723	189.625	311.765	13.54425	0.4508800	440.7606	0.7099179	693.9847
28115	11.835898	190.890	311.765	13.54425	0.5464824	460.7463	0.7702317	649.3922
28173	12.137410	190.890	311.765	13.54425	0.4296046	358.8882	0.6714843	560.9525
28230	10.980491	191.705	311.765	13.54425	0.5852610	448.2531	0.7520011	575.9598
28288	11.367163	191.590	311.765	13.54425	0.4718032	380.6107	0.6634170	535.1884
28346	9.629919	192.630	311.765	13.54425	0.3877601	294.5171	0.4716950	358.2686
28404	10.093547	189.160	311.765	13.54425	0.3682637	293.3870	0.4936838	393.3062
28461	10.623536	189.650	311.765	13.54425	0.5435154	414.5463	0.6968373	531.4869
28519	10.158903	191.375	311.765	13.54425	0.4501274	354.2285	0.5693076	448.0175
28577	11.533163	193.100	311.765	13.54425	0.8373257	636.6087	1.0329391	785.3312
28634	11.374452	192.820	311.765	13.54425	0.6235308	474.4443	0.8102970	616.5546
28692	10.841498	193.310	311.765	13.54425	0.7029885	537.9448	0.8536153	653.2083
28750	9.422903	193.845	311.765	13.54425	0.4158887	302.6093	0.4823137	350.9415
28845	10.694589	193.290	311.765	13.54425	0.4318487	345.0828	0.5759184	460.2064
28979	11.499752	193.065	311.765	13.54425	0.6586987	490.9787	0.8523618	635.3307
29113	11.120728	192.260	311.765	13.54425	0.5211087	392.8660	0.6946480	523.6980

age_calBP	past_temp	past_co2	modern_co2	present_t	recon_mi	recon_Pann	corr_mi	corr_Pann
29247	10.753886	190.245	311.765	13.54425	0.5171989	401.4079	0.6763539	524.9312
29381	11.756357	189.520	311.765	13.54425	0.4878861	398.5691	0.7121936	581.8128
29515	11.037277	189.225	311.765	13.54425	0.3685841	295.6297	0.5501620	441.2676
29649	11.111456	189.505	311.765	13.54425	0.2794845	241.9519	0.4647340	402.3238
29782	10.913739	191.125	311.765	13.54425	0.3377912	313.6466	0.5044079	468.3539
29916	10.914002	191.175	311.765	13.54425	0.3202582	262.4015	0.4868079	398.8629
30050	10.655553	189.910	311.765	13.54425	0.4837099	382.7226	0.6385005	505.1966
30184	11.561990	188.480	311.765	13.54425	0.3432502	278.0887	0.5596381	453.3983
30318	10.091858	185.990	311.765	13.54425	0.3187872	251.3405	0.4578235	360.9605
30386	11.604128	185.145	311.765	13.54425	0.3738220	348.3823	0.6070900	565.7757
30455	11.523392	183.620	311.765	13.54425	0.3811901	302.4871	0.6162075	488.9813
30524	11.725373	183.620	311.765	13.54425	0.6385906	489.9844	0.8873083	680.8231
30592	10.603525	185.040	311.765	13.54425	0.6667504	515.5632	0.8371965	647.3603