Lago di Fimon Data: MI and Pann corrections

(45.469951, 11.543468)

Obtain palaeo (past) CO2 from (Bereiter et al. 2015)

```
palaeo_co2 <- fimon %$%
  purrr::map_dbl(age_cal_yr_BP, codos::past_co2)
```

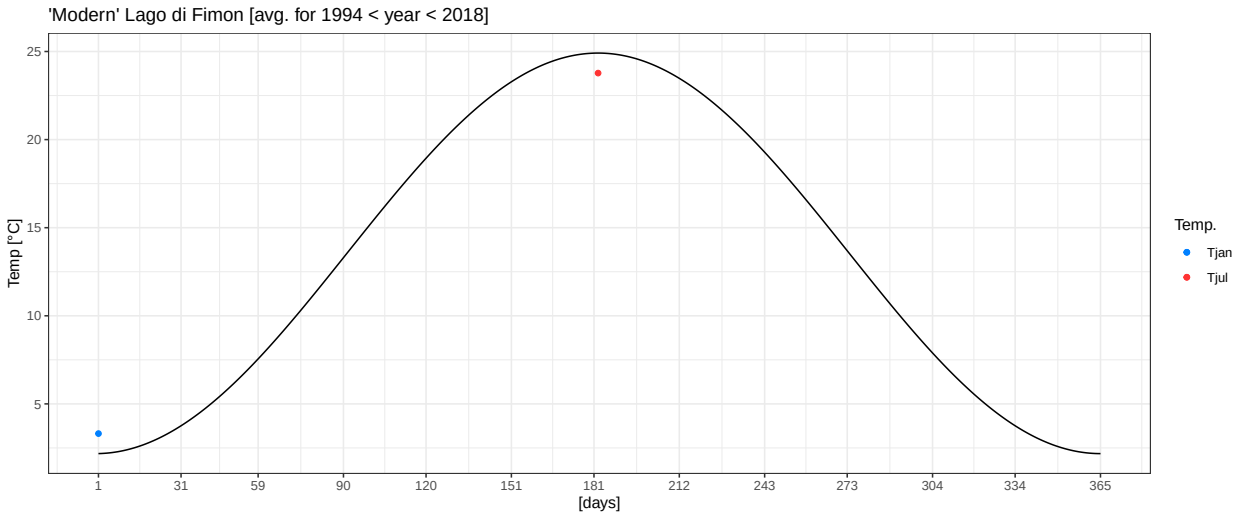
Obtain modern CO2 from (Bereiter et al. 2015)

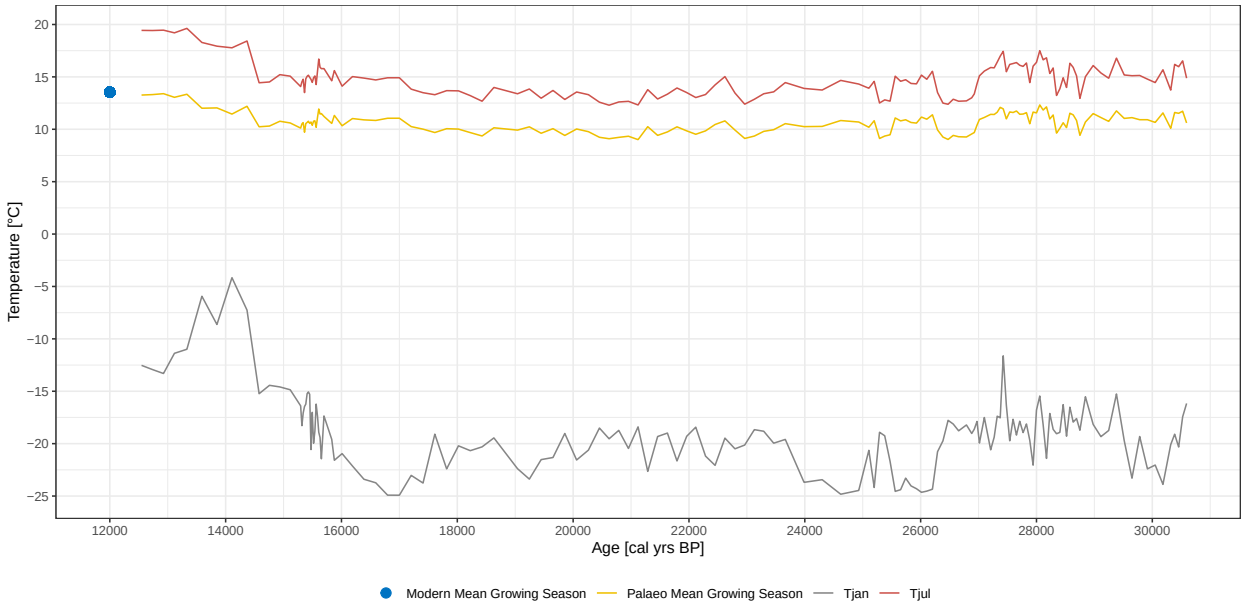
```
modern_co2 <- tibble::tibble(age = 1950 - c(1901:1990),
                             co2 = purrr::map_dbl(age, codos::past_co2)) %$%
  median(co2)
```

Read "modern" data - Quinto Vicentino station

```
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

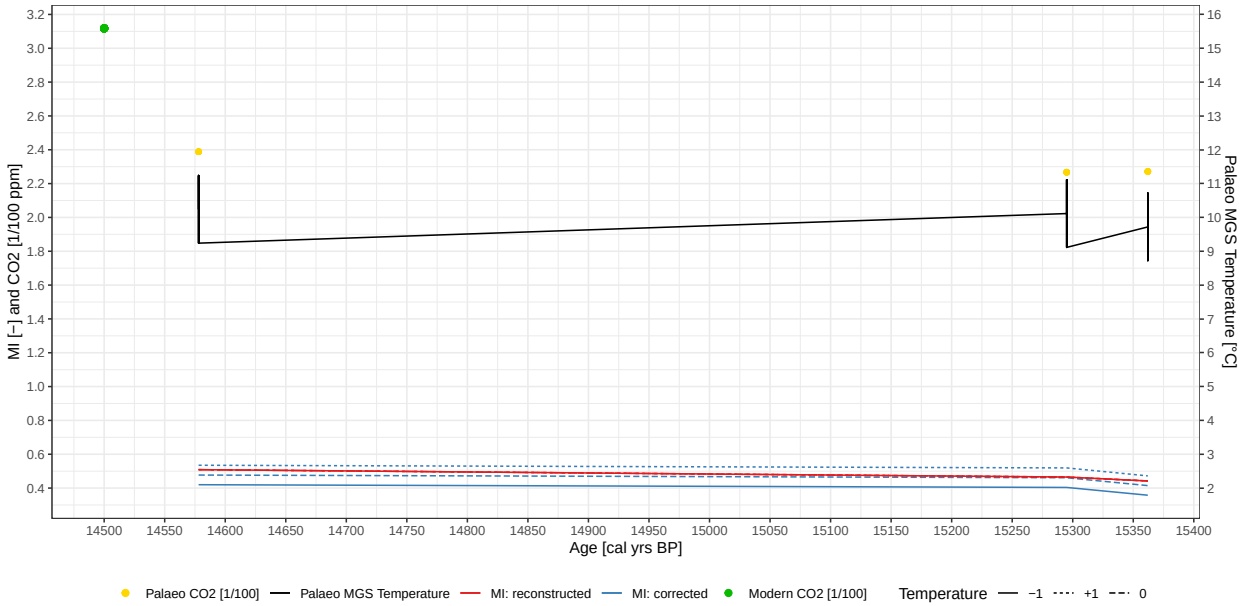
```
fimon2 <- tibble::tibble(age_calBP = fimon$age_cal_yr_BP,
                         palaeo_co2 = palaeo_co2,
                         palaeo_MGS_temp = fimon$Tgs,
                         modern_co2 = modern_co2,
                         modern_MGS_temp = mean(quinto_vicentino_tmp),
                         recon_mi = fimon$MI,
                         recon_Pann = fimon$Pann)
```

Find the corrected MI

```
corr_mi <- fimon2 %$%
  codos::corrected_mi(Tc0 = modern_MGS_temp,
                      Tc1 = palaeo_MGS_temp,
                      MI = recon_mi,
                      ca0 = modern_co2,
                      ca1 = palaeo_co2)
fimon2 <- fimon2 %>%
  dplyr::mutate(corr_mi = corr_mi)
```

Records for which the corrected MI is smaller than reconstructed MI

age cal yr BP	palaeo co2	palaeo MGS temp	modern co2	modern MGS temp	recon. MI	recon. Pann	corr. MI
14578	238.870	10.239288	311.765	13.54425	0.5087981	404.7196	0.4769689
15295	226.705	10.113954	311.765	13.54425	0.4651172	373.2063	0.4610480
15362	227.155	9.718953	311.765	13.54425	0.4419405	335.6987	0.4145272

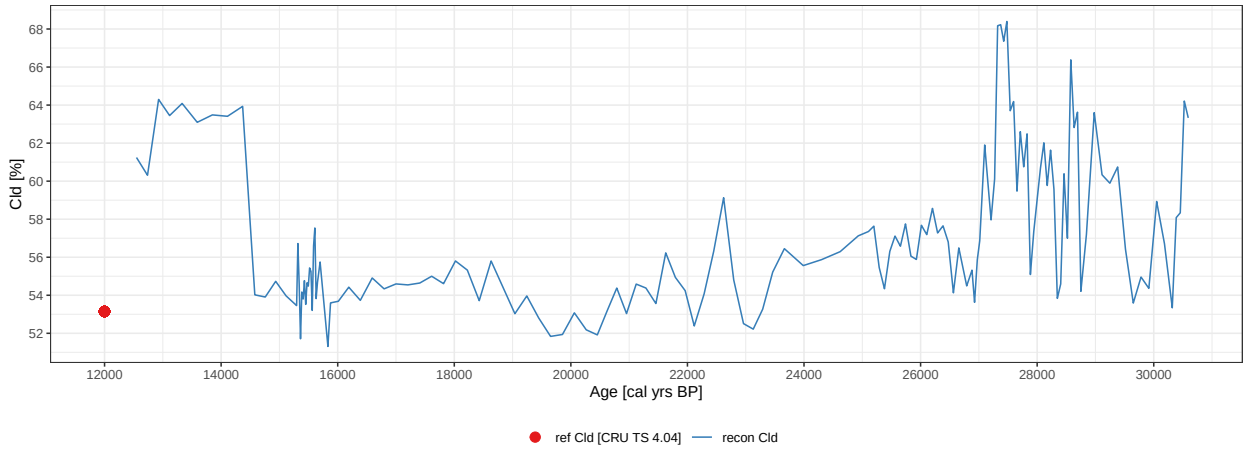

MI [−] and CO2 [1/100 ppm]
Palaeo MGS Temperature [°C]
Age [cal yrs BP]
Palaeo CO2 [1/100]
Palaeo MGS Temperature
MI: reconstructed
MI: corrected
Modern CO2 [1/100]
Temperature
−1
+1
0

New corrections

Find anomalies (`Tmp` and `cld`)

Data from the weather station Quinto Vicentino was used as the baseline to calculate the temperature anomalies and data from the CRU TS 4.04 dataset for the baseline cloud coverage, 53.1437681.

Cloud coverage from corrected MI

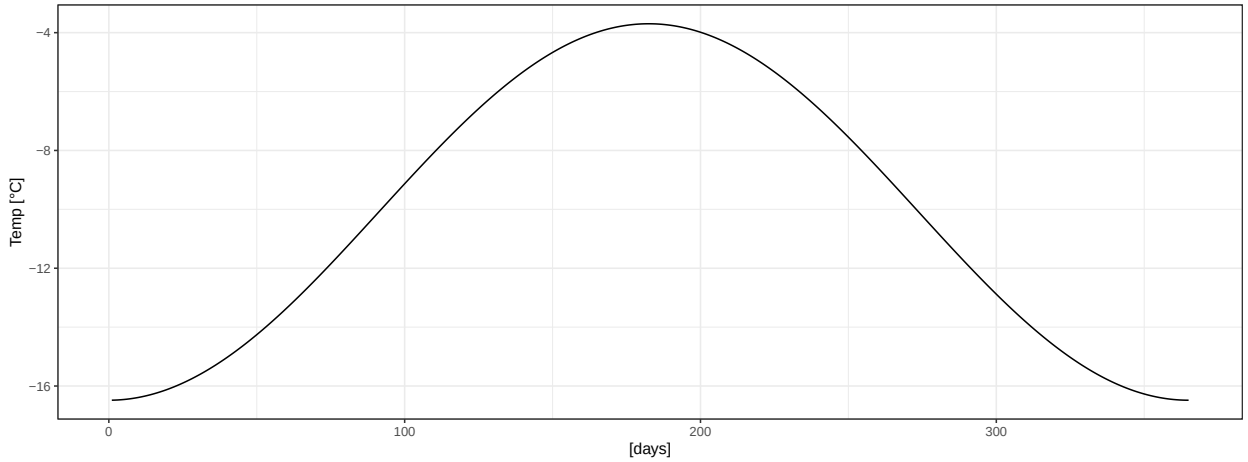



```
fimon_tmp_anomalies <- seq_len(nrow(fimon)) %>%
  purrr::map(~codos::int_sin(fimon$Tmin[.x] - fimon_modern$Tmin,
                             fimon$Tmax[.x] - fimon_modern$Tmax))

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
```

Temperature anomalies

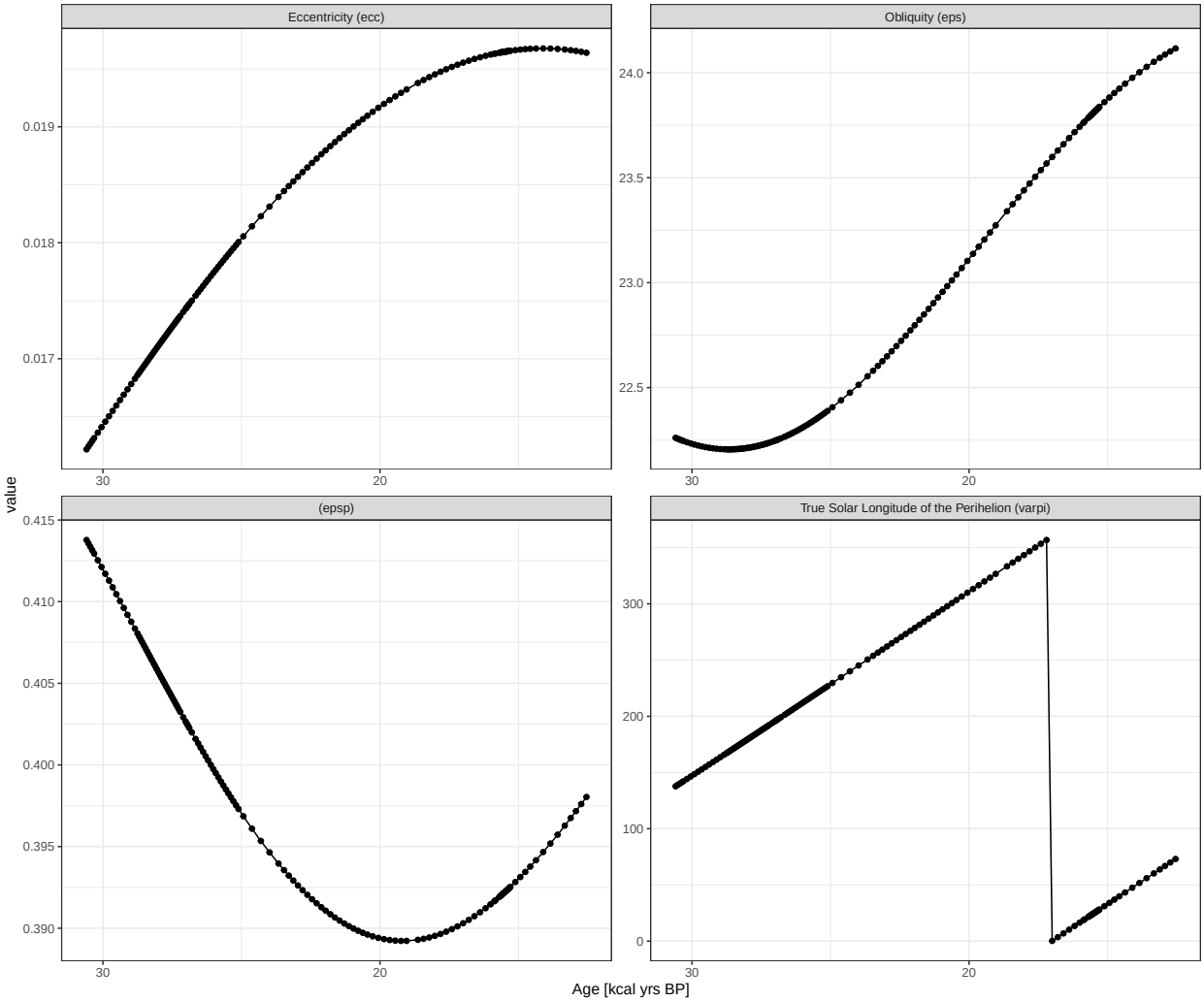
Lago di Fimon: Anomalies for age = 12548 cal yr BP



Find orbital parameters

Selected samples and their orbital parameters:

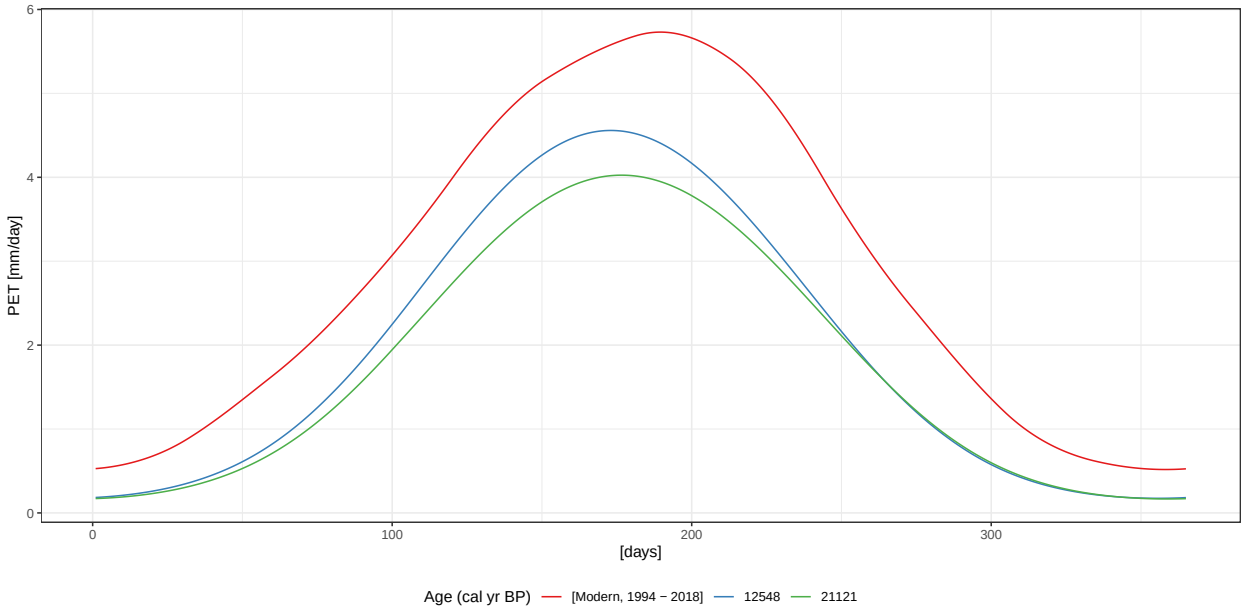
year	eps	ecc	varpi	epsp
12548	24.11564	0.0196384	73.05159	0.3980368
12737	24.10148	0.0196468	69.95812	0.3976019
12927	24.08645	0.0196542	66.84861	0.3971713
13116	24.07073	0.0196605	63.75573	0.3967500
21121	22.92946	0.0189703	292.43144	0.3901260
30592	22.26079	0.0162180	137.72150	0.4137755



Calculate potential evapotranspiration (PET)

Params (`splash::calc_daily_evap`)

- Latitude: 45.469951
- Elevation: 8
- Sunshine fraction: [`CRU TS 4.04`] $+\text{Cld}_{\text{anomalies}}$
- Temperature: [`Quinto Vicentino station`] $+\text{Tmp}_{\text{anomalies}}$



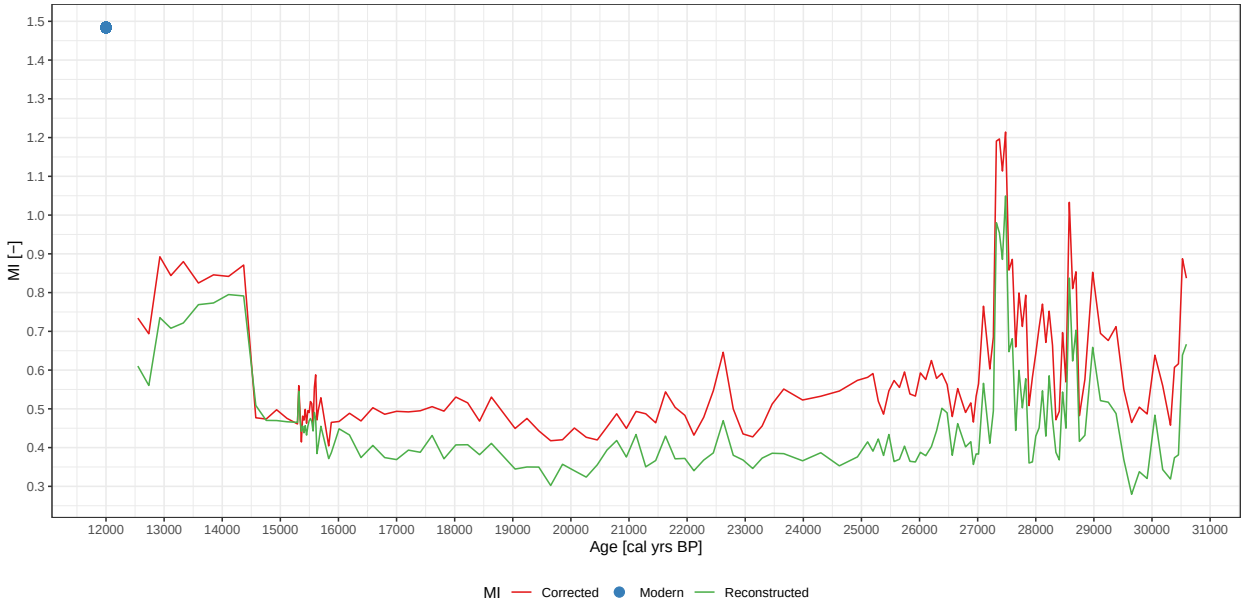
Calculate estimated Precipitation

$$\text{estimated } P_{\text{ann}} = \text{MI} \times \text{PET}_{\text{ann}}$$

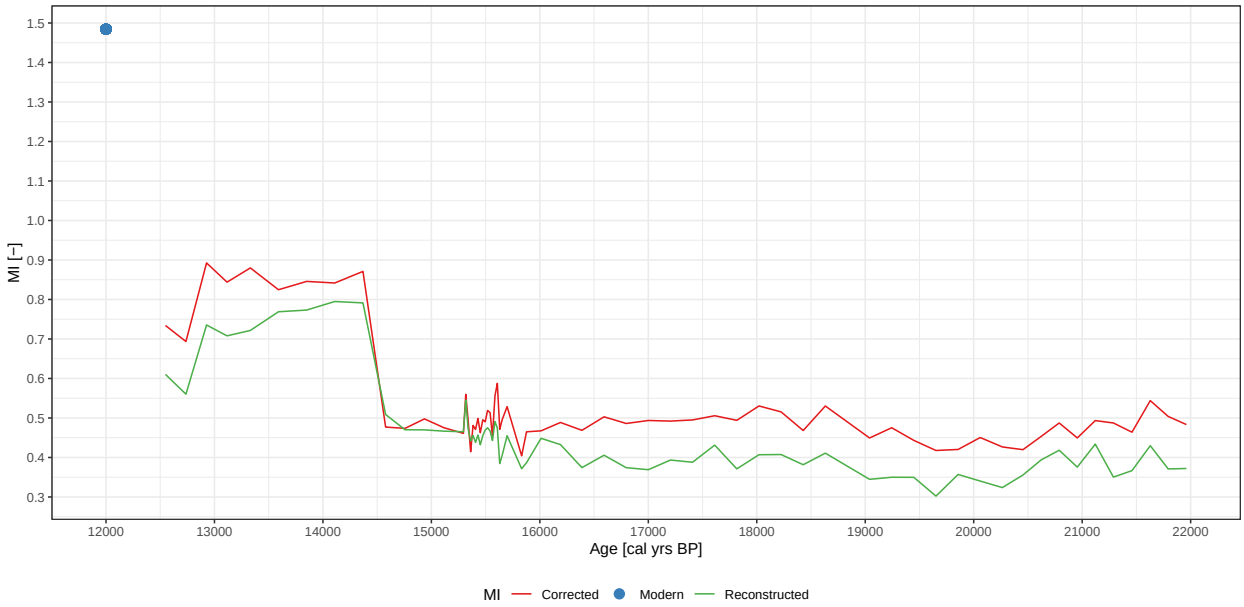
age [cal yrs BP]	recon. MI	recon. Pann	corrected MI	estimated Pann (Tmp + Cld anomalies & Orb. Par.)
12548	0.6104173	580.6471	0.7342405	523.9785
12737	0.5603200	531.1387	0.6936090	503.4221
12927	0.7353834	671.8961	0.8925061	589.4234
13116	0.7079373	663.4637	0.8439122	574.3824
13331	0.7216559	658.5455	0.8799385	596.2966
13590	0.7688588	650.2817	0.8246798	580.8375
13850	0.7732308	627.7127	0.8457674	572.8826
14109	0.7948950	649.0931	0.8417454	590.8360
14369	0.7913471	639.3712	0.8710726	595.3550
14578	0.5087981	404.7196	0.4769689	345.6542
14757	0.4701792	381.7680	0.4736902	346.8363

Plots

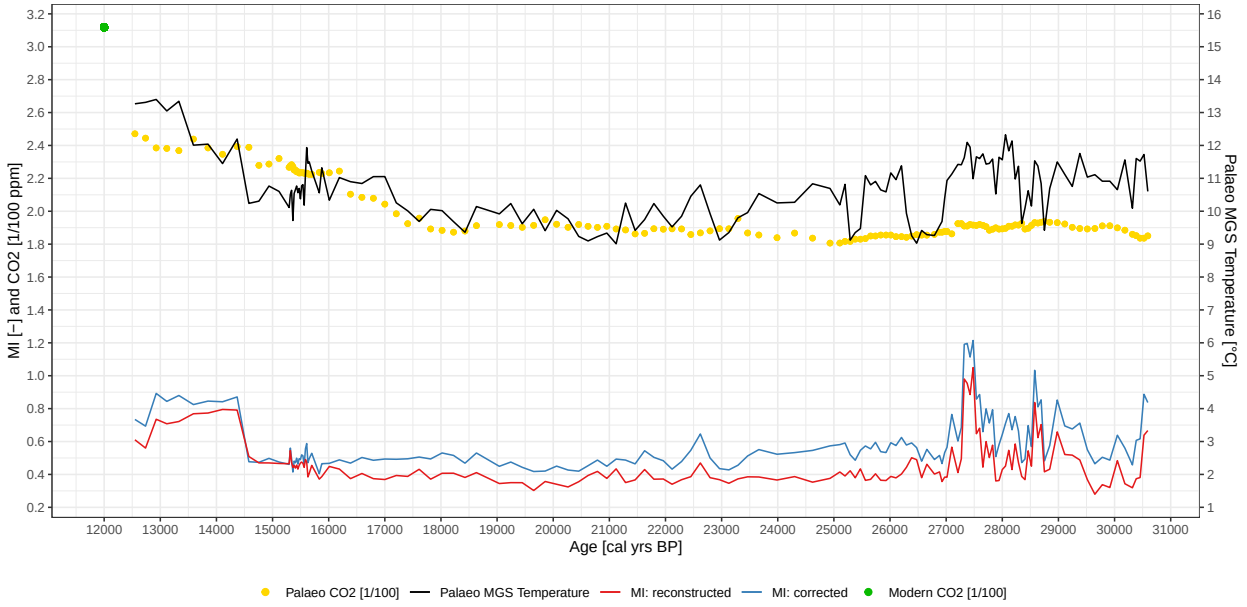
Reconstructed vs corrected `MI`: Past CO2 calculated using `mean`



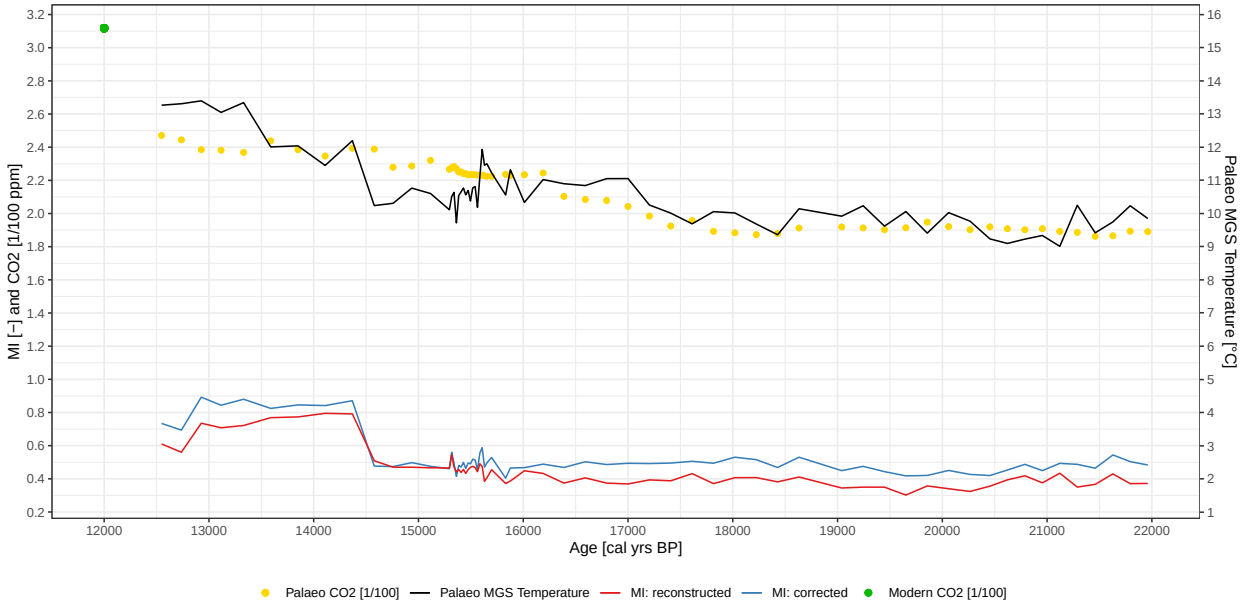
- `age < 22k`



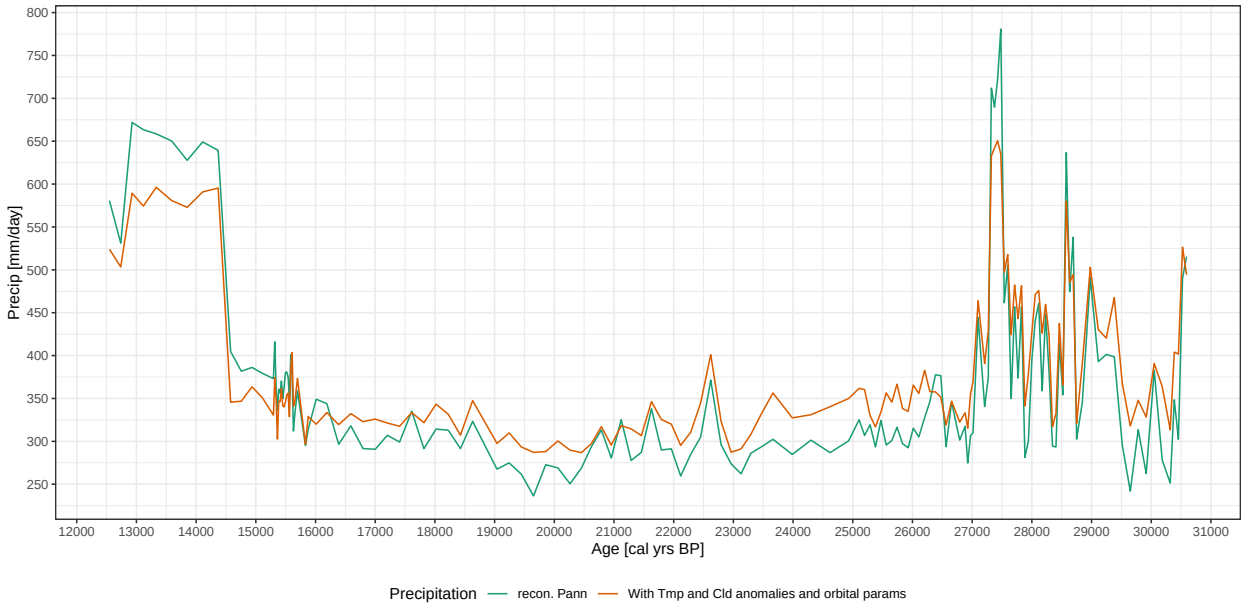
Include past CO2 and Temperature



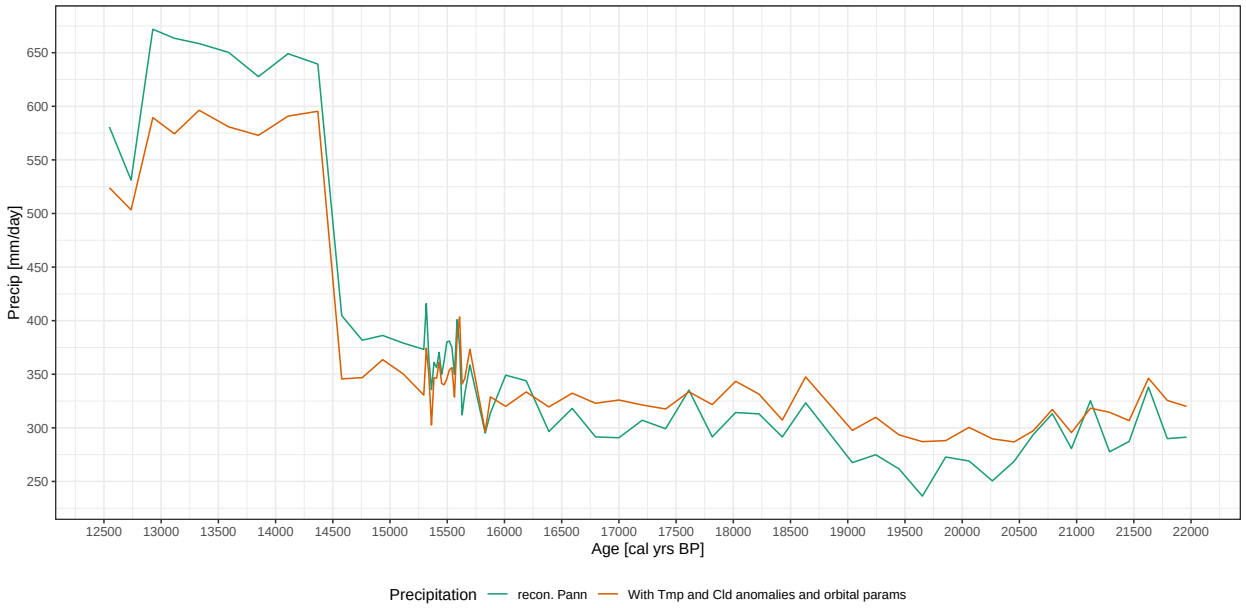
- age < 22k



Reconstructed vs estimated `Pann`



`age < 22k`



Appendix

A1. Lago di Fimon Data

age [cal yr BP]	palaeo co2 [umol/mol]	palaeo MGS temp [°C]	modern co2 [umol/mol]	modern MGS temp [°C]	recon. MI [-]	recon. Pann [mm/day]	corr. MI [-]	est. Pann [mm/day]
12548	247.095	13.266217	311.765	13.54425	0.6104173	580.6471	0.7342405	523.9785
12737	244.445	13.310121	311.765	13.54425	0.5603200	531.1387	0.6936090	503.4221
12927	238.485	13.398367	311.765	13.54425	0.7353834	671.8961	0.8925061	589.4234
13116	238.190	13.049074	311.765	13.54425	0.7079373	663.4637	0.8439122	574.3824
13331	236.860	13.343179	311.765	13.54425	0.7216559	658.5455	0.8799385	596.2966
13590	243.860	12.008586	311.765	13.54425	0.7688588	650.2817	0.8246798	580.8375
13850	238.515	12.040088	311.765	13.54425	0.7732308	627.7127	0.8457674	572.8826
14109	234.640	11.449482	311.765	13.54425	0.7948950	649.0931	0.8417454	590.8360
14369	239.360	12.195733	311.765	13.54425	0.7913471	639.3712	0.8710726	595.3550
14578	238.870	10.239288	311.765	13.54425	0.5087981	404.7196	0.4769689	345.6542
14757	227.900	10.307509	311.765	13.54425	0.4701792	381.7680	0.4736902	346.8363
14936	228.680	10.765795	311.765	13.54425	0.4698498	386.1915	0.4976559	363.6096
15115	232.070	10.603367	311.765	13.54425	0.4666316	379.1291	0.4753819	350.3117
15295	226.705	10.113954	311.765	13.54425	0.4651172	373.2063	0.4610480	330.5774
15317	227.640	10.510248	311.765	13.54425	0.5454642	415.9699	0.5599306	374.4079
15339	228.280	10.636228	311.765	13.54425	0.4719894	365.1981	0.4933968	349.7556
15362	227.155	9.718953	311.765	13.54425	0.4419405	335.6987	0.4145272	302.6453
15384	225.065	10.539899	311.765	13.54425	0.4556153	360.9716	0.4812180	346.6155
15407	225.065	10.654296	311.765	13.54425	0.4382268	356.2088	0.4707850	346.3633
15429	224.005	10.767674	311.765	13.54425	0.4567170	370.4210	0.4987160	361.4925
15451	224.005	10.562954	311.765	13.54425	0.4322369	349.7368	0.4627942	341.3405
15474	223.270	10.695030	311.765	13.54425	0.4554099	363.2278	0.4954255	340.1413
15496	223.400	10.377678	311.765	13.54425	0.4693971	380.0470	0.4902907	345.7341
15518	223.400	10.773269	311.765	13.54425	0.4751379	380.9936	0.5189900	353.9031
15541	223.400	10.810595	311.765	13.54425	0.4672453	375.0532	0.5134085	356.1874
15563	223.145	10.185928	311.765	13.54425	0.4428890	349.9122	0.4540286	328.6895
15586	223.145	11.124733	311.765	13.54425	0.4908755	400.9151	0.5559204	383.8499
15608	223.145	11.935365	311.765	13.54425	0.4745624	376.6003	0.5877322	403.4087

age [cal yr BP]	palaeo co2 [umol/mol]	palaeo MGS temp [°C]	modern co2 [umol/mol]	modern MGS temp [°C]	recon. MI [-]	recon. Pann [mm/day]	corr. MI [-]	est. Pann [mm/day]
15630	222.760	11.456396	311.765	13.54425	0.3846061	312.0294	0.4713694	340.8296
15653	222.460	11.500779	311.765	13.54425	0.4059562	331.6249	0.4960506	345.8964
15698	222.460	11.226957	311.765	13.54425	0.4550534	358.6714	0.5286480	373.3423
15832	223.610	10.560156	311.765	13.54425	0.3715463	295.1067	0.4042802	296.6081
15877	222.935	11.321146	311.765	13.54425	0.3866602	313.7987	0.4650201	328.8948
16011	223.400	10.335111	311.765	13.54425	0.4485396	349.1470	0.4674070	320.0268
16190	224.405	11.023666	311.765	13.54425	0.4325579	343.9236	0.4886168	333.5236
16388	210.360	10.898787	311.765	13.54425	0.3743157	296.5703	0.4687477	319.4849
16592	208.460	10.843108	311.765	13.54425	0.4056510	318.1669	0.5029202	332.3258
16796	207.890	11.051719	311.765	13.54425	0.3742106	291.5290	0.4860529	322.9234
17000	204.320	11.053536	311.765	13.54425	0.3690658	290.7584	0.4936389	325.9415
17204	198.460	10.256339	311.765	13.54425	0.3934976	307.0949	0.4921347	321.3421
17408	192.455	10.011196	311.765	13.54425	0.3879071	299.1497	0.4950338	317.5661
17612	195.790	9.688878	311.765	13.54425	0.4312829	335.1350	0.5056728	333.6190
17816	189.230	10.056964	311.765	13.54425	0.3711237	291.5426	0.4940448	321.6871
18020	188.375	10.017040	311.765	13.54425	0.4069588	314.2815	0.5303886	343.4343
18224	187.265	9.683744	311.765	13.54425	0.4074088	313.0220	0.5154561	331.5057
18428	187.960	9.360746	311.765	13.54425	0.3816363	291.5168	0.4682690	307.2668
18632	191.235	10.143186	311.765	13.54425	0.4109214	323.3310	0.5303244	347.4980
19040	191.900	9.919833	311.765	13.54425	0.3446474	267.5633	0.4493288	297.6014
19244	191.335	10.234145	311.765	13.54425	0.3499654	274.9005	0.4752935	309.8043
19448	190.235	9.619730	311.765	13.54425	0.3497317	261.6832	0.4432444	293.4518
19652	191.420	10.059559	311.765	13.54425	0.3022315	236.3271	0.4177130	287.1194
19856	194.830	9.409042	311.765	13.54425	0.3569768	272.7675	0.4203086	288.0861
20060	192.095	10.026597	311.765	13.54425	0.3402560	269.0825	0.4505216	300.4071
20264	190.230	9.770067	311.765	13.54425	0.3238047	250.5088	0.4266693	289.7533
20454	191.960	9.235206	311.765	13.54425	0.3555843	268.7711	0.4197606	286.8616
20621	190.845	9.097524	311.765	13.54425	0.3936621	293.6537	0.4530966	297.2759
20788	190.210	9.228258	311.765	13.54425	0.4183326	313.2123	0.4872958	317.1260
20955	190.870	9.336702	311.765	13.54425	0.3756592	280.6580	0.4494878	295.5659
21121	189.225	9.010375	311.765	13.54425	0.4338236	325.3255	0.4933797	318.3359
21288	188.645	10.248790	311.765	13.54425	0.3503193	277.6850	0.4873017	314.5271
21459	186.235	9.417773	311.765	13.54425	0.3666595	287.2509	0.4639955	306.7322

age [cal yr BP]	palaeo co2 [umol/mol]	palaeo MGS temp [°C]	modern co2 [umol/mol]	modern MGS temp [°C]	recon. MI [-]	recon. Pann [mm/day]	corr. MI [-]	est. Pann [mm/day]
21628	186.595	9.747203	311.765	13.54425	0.4297748	338.0219	0.5439386	346.2565
21793	189.370	10.233587	311.765	13.54425	0.3710240	289.9326	0.5038784	325.5828
21961	189.080	9.849288	311.765	13.54425	0.3720975	291.2695	0.4832948	320.0122
22117	189.325	9.524081	311.765	13.54425	0.3403084	259.6103	0.4320232	295.2383
22286	189.245	9.847777	311.765	13.54425	0.3678182	284.8942	0.4783421	310.7079
22451	185.850	10.455059	311.765	13.54425	0.3863056	304.9136	0.5467457	344.7492
22621	186.850	10.801068	311.765	13.54425	0.4695378	371.4407	0.6460814	400.9846
22794	188.070	9.925817	311.765	13.54425	0.3802290	296.1362	0.4999055	323.2749
22962	189.400	9.123159	311.765	13.54425	0.3679825	273.8504	0.4352679	287.3072
23129	189.340	9.352415	311.765	13.54425	0.3461524	262.1023	0.4276317	291.2156
23291	195.600	9.801209	311.765	13.54425	0.3728354	285.9903	0.4558016	307.8752
23463	186.780	9.959096	311.765	13.54425	0.3854142	293.2969	0.5122686	331.2257
23663	185.560	10.538265	311.765	13.54425	0.3843895	302.3884	0.5510851	356.4278
23987	183.905	10.253437	311.765	13.54425	0.3659864	284.7319	0.5227800	327.3723
24300	186.730	10.272106	311.765	13.54425	0.3867717	301.3982	0.5325339	331.0835
24620	183.650	10.835434	311.765	13.54425	0.3529370	286.8193	0.5459690	340.3798
24931	180.630	10.693080	311.765	13.54425	0.3759896	300.6213	0.5735241	349.9391
25106	180.690	10.192470	311.765	13.54425	0.4148334	325.1340	0.5813092	361.8286
25198	181.675	10.817728	311.765	13.54425	0.3907004	306.8630	0.5911076	360.3118
25290	181.675	9.121652	311.765	13.54425	0.4221757	319.3260	0.5196829	329.9761
25380	183.020	9.352006	311.765	13.54425	0.3796770	293.5128	0.4861884	316.9185
25472	183.020	9.473377	311.765	13.54425	0.4338403	324.3084	0.5464453	334.0877
25561	183.380	11.083272	311.765	13.54425	0.3639550	295.7344	0.5731359	356.5832
25654	184.960	10.801333	311.765	13.54425	0.3700087	300.9135	0.5552463	345.7151
25741	184.960	10.906940	311.765	13.54425	0.4037598	316.4436	0.5952171	366.6660
25834	185.530	10.649276	311.765	13.54425	0.3646720	297.2957	0.5383534	338.2592
25928	185.530	10.588668	311.765	13.54425	0.3628614	292.4988	0.5329136	335.0056
26014	185.530	11.165762	311.765	13.54425	0.3878914	315.2895	0.5927265	365.6389
26106	184.545	10.960727	311.765	13.54425	0.3790444	305.1368	0.5756728	355.7724
26204	184.570	11.381895	311.765	13.54425	0.4025573	327.5677	0.6247553	382.8346
26292	184.170	9.936640	311.765	13.54425	0.4431722	346.4735	0.5786691	357.9307
26385	184.890	9.257054	311.765	13.54425	0.5014990	377.5408	0.5916827	357.6934
26474	185.760	9.027001	311.765	13.54425	0.4896647	376.6521	0.5626716	351.7018

age [cal yr BP]	palaeo co2 [umol/mol]	palaeo MGS temp [°C]	modern co2 [umol/mol]	modern MGS temp [°C]	recon. MI [-]	recon. Pann [mm/day]	corr. MI [-]	est. Pann [mm/day]
26563	185.510	9.415805	311.765	13.54425	0.3801492	293.6164	0.4800468	319.0640
26656	185.475	9.288182	311.765	13.54425	0.4618198	345.8594	0.5523869	346.8370
26791	185.935	9.263657	311.765	13.54425	0.4019588	301.4909	0.4905895	322.4792
26882	187.255	9.552970	311.765	13.54425	0.4152275	317.4304	0.5153621	333.3383
26926	187.255	9.689455	311.765	13.54425	0.3564121	274.7229	0.4658377	315.3586
26973	187.735	10.389917	311.765	13.54425	0.3836743	306.6781	0.5323769	355.5510
27015	187.735	10.936895	311.765	13.54425	0.3831848	310.0836	0.5648133	369.5246
27100	186.270	11.129036	311.765	13.54425	0.5658541	444.3265	0.7647902	463.9150
27209	192.495	11.424672	311.765	13.54425	0.4112296	340.5462	0.6027686	390.7261
27270	192.495	11.411419	311.765	13.54425	0.4946910	374.1085	0.6853063	428.6173
27322	191.005	11.626774	311.765	13.54425	0.9801671	711.9451	1.1909620	632.8764
27374	191.005	12.094544	311.765	13.54425	0.9541025	689.6757	1.1964967	641.9453
27426	191.950	11.947412	311.765	13.54425	0.8856040	721.7586	1.1136261	650.5561
27480	191.590	10.988989	311.765	13.54425	1.0492718	780.7094	1.2142380	634.9394
27538	191.380	11.655281	311.765	13.54425	0.6474583	461.6283	0.8580021	497.2681
27596	191.950	11.600494	311.765	13.54425	0.6810894	505.3575	0.8857966	517.7542
27654	191.460	11.745321	311.765	13.54425	0.4442326	349.9552	0.6596326	424.2868
27711	190.610	11.432715	311.765	13.54425	0.5994570	457.0705	0.7990589	482.3579
27769	188.445	11.454023	311.765	13.54425	0.5024990	373.8128	0.7125531	443.1608
27827	189.085	11.585765	311.765	13.54425	0.5776934	456.5127	0.7933689	481.5677
27884	189.930	10.525778	311.765	13.54425	0.3602705	281.2339	0.5083940	341.1970
27942	189.140	11.641609	311.765	13.54425	0.3630040	300.4253	0.5814915	379.0670
28000	189.290	11.563750	311.765	13.54425	0.4296742	395.2297	0.6428969	426.7223
28057	189.625	12.324723	311.765	13.54425	0.4508800	440.7606	0.7099179	471.2000
28115	190.890	11.835898	311.765	13.54425	0.5464824	460.7463	0.7702317	475.8545
28173	190.890	12.137410	311.765	13.54425	0.4296046	358.8882	0.6714843	426.1582
28230	191.705	10.980491	311.765	13.54425	0.5852610	448.2531	0.7520011	459.7097
28288	191.590	11.367163	311.765	13.54425	0.4718032	380.6107	0.6634170	423.8134
28346	192.630	9.629919	311.765	13.54425	0.3877601	294.5171	0.4716950	317.1004
28404	189.160	10.093547	311.765	13.54425	0.3682637	293.3870	0.4936838	332.6389
28461	189.650	10.623536	311.765	13.54425	0.5435154	414.5463	0.6968373	437.4852
28519	191.375	10.158903	311.765	13.54425	0.4501274	354.2285	0.5693076	365.7109
28577	193.100	11.533163	311.765	13.54425	0.8373257	636.6087	1.0329391	580.0619

age [cal yr BP]	palaeo co2 [umol/mol]	palaeo MGS temp [°C]	modern co2 [umol/mol]	modern MGS temp [°C]	recon. MI [-]	recon. Pann [mm/day]	corr. MI [-]	est. Pann [mm/day]
28634	192.820	11.374452	311.765	13.54425	0.6235308	474.4443	0.8102970	485.4583
28692	193.310	10.841498	311.765	13.54425	0.7029885	537.9448	0.8536153	494.3608
28750	193.845	9.422903	311.765	13.54425	0.4158887	302.6093	0.4823137	321.1367
28845	193.290	10.694589	311.765	13.54425	0.4318487	345.0828	0.5759184	390.7196
28979	193.065	11.499752	311.765	13.54425	0.6586987	490.9787	0.8523618	502.9256
29113	192.260	11.120728	311.765	13.54425	0.5211087	392.8660	0.6946480	430.2118
29247	190.245	10.753886	311.765	13.54425	0.5171989	401.4079	0.6763539	420.3766
29381	189.520	11.756357	311.765	13.54425	0.4878861	398.5691	0.7121936	467.5813
29515	189.225	11.037277	311.765	13.54425	0.3685841	295.6297	0.5501620	367.4873
29649	189.505	11.111456	311.765	13.54425	0.2794845	241.9519	0.4647340	318.0498
29782	191.125	10.913739	311.765	13.54425	0.3377912	313.6466	0.5044079	347.9060
29916	191.175	10.914002	311.765	13.54425	0.3202582	262.4015	0.4868079	328.3460
30050	189.910	10.655553	311.765	13.54425	0.4837099	382.7226	0.6385005	390.7778
30184	188.480	11.561990	311.765	13.54425	0.3432502	278.0887	0.5596381	363.8826
30318	185.990	10.091858	311.765	13.54425	0.3187872	251.3405	0.4578235	313.4293
30386	185.145	11.604128	311.765	13.54425	0.3738220	348.3823	0.6070900	404.0165
30455	183.620	11.523392	311.765	13.54425	0.3811901	302.4871	0.6162075	401.8095
30524	183.620	11.725373	311.765	13.54425	0.6385906	489.9844	0.8873083	526.3605
30592	185.040	10.603525	311.765	13.54425	0.6667504	515.5632	0.8371965	494.3492