



Supplement of

Early winter barium excess in the southern Indian Ocean as an annual remineralisation proxy (GEOTRACES GIPr07 cruise)

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2**Table S1: Particulate Ba (pBa), particulate Al (pAl) and barium excess (Ba_{xs}) profile concentrations for seven stations along the 30°E transect study during winter 2017.**

Station Latitude (°S), Longitude (°E)	Depth (m)	pBa (pmol L ⁻¹)	pAl (nmol L ⁻¹)	Ba _{xs} (pmol L ⁻¹)
TM1 58.5°S, 30°E	25	134	0.76	133
	75	131	1.09	130
	100	193	0.77	192
	150	153	1.18	151
	200	340	0.58	339
	250	357	1.25	355
	299	375	0.29	375
	349	343	0.78	342
	401	352	0.84	351
	451	271	0.36	271
	500	229	0.33	229
	550	150	1.98	147
	751	256	1.63	254
	1001	203	1.20	201
1250	245	1.45	243	
1500	207	1.47	205	
TM2 56°S, 30°E	25	127	0.72	126
	51	121	1.30	119
	76	113	0.74	112
	100	113	0.31	113
	150	271	0.57	270
	201	248	0.25	248
	250	311	0.69	310
	300	453	0.82	452
	401	356	1.11	355
	501	315	0.75	314
	599	253	0.74	252
	701	228	0.48	227
	801	224	0.98	223
901	235	1.17	233	
1001	228	1.46	226	

	1250	235	1.33	233
	1751	206	1.68	204
	2250	192	1.94	189
	2769	163	2.03	160
	3500	194	2.83	190
	26	121	0.67	120
	75	132	0.79	131
	99	154	1.39	152
	151	536	0.28	536
	200	634	0.67	633
	250	560	0.92	559
	300	607	0.97	606
	399	155	0.66	154
TM4	501	399	1.20	397
50.5°S,	602	289	0.64	288
30°E	701	271	0.93	270
	799	281	0.68	280
	901	245	1.29	243
	999	361	2.92	357
	1250	225	2.18	222
	2000	164	1.37	162
	2502	183	2.52	180
	3001	163	3.41	158
	3501	249	6.24	241

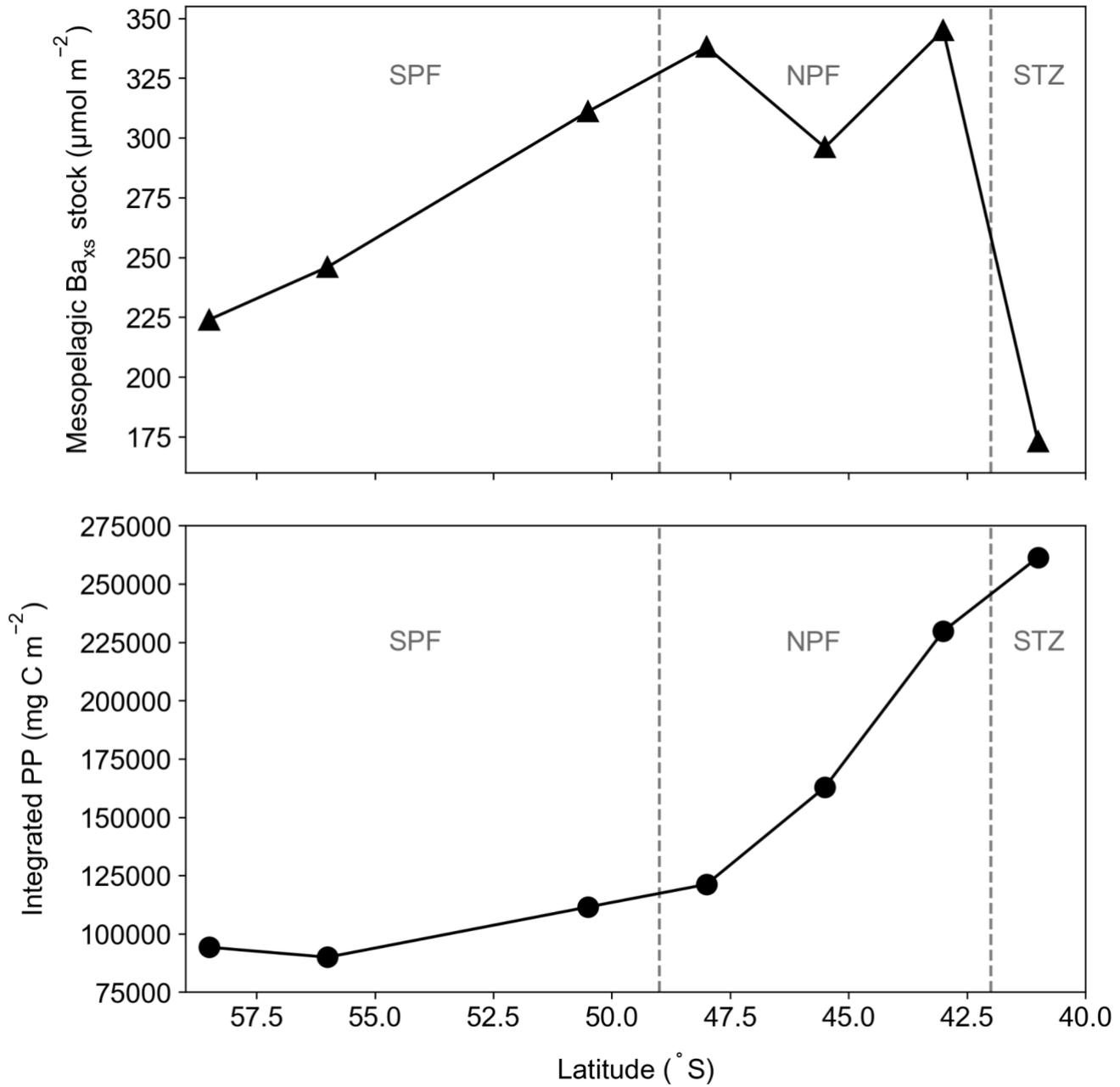
	26	143	0.88	142
	50	135	1.63	133
	75	113	0.86	112
	100	127	0.39	126
	150	627	1.46	625
	201	349	0.58	348
	251	686	1.29	684
	301	561	1.61	559
TM5	400	510	1.15	508
48°S,	501	368	1.89	365
30°E	601	318	1.72	316
	700	185	0.95	184
	802	320	1.67	318
	900	305	1.54	303
	1000	342	2.12	339
	1752	308	2.44	305
	2250	187	2.09	184
	2751	186	2.03	183
	3501	136	2.03	133
	4251	92	2.97	88

TM6 45.5°S, 30°E	23	89	0.66	88
	76	83	0.64	82
	101	92	0.72	91
	149	115	1.28	113
	200	128	1.01	127
	251	639	2.99	635
	300	285	1.24	283
	400	439	3.48	434
	598	404	3.74	399
	701	299	3.50	294
	800	319	3.11	315
	902	323	4.01	318
	1000	348	2.76	344
	1249	218	1.86	215
	1750	257	2.32	254
	2249	188	2.50	185
	2750	180	3.68	175
3500	116	2.27	113	
4249	82	2.98	78	
TM7 43°S, 30°E	26	102	0.99	101
	75	109	1.13	107
	101	128	1.47	126
	126	114	1.13	112
	150	129	1.13	127
	175	158	1.16	156
	202	619	2.01	616
	253	559	1.85	557
	301	570	1.70	568
	400	364	2.23	361
	500	480	2.59	477
	750	380	2.29	377
	1008	272	2.74	268
	1250	260	4.74	254
1503	280	3.35	275	
TM8	25	61	1.53	59
41°S,	76	74	1.98	71
30°E	100	76	2.55	73

120	159	1.24	157
151	211	2.15	208
175	169	2.50	166
200	207	2.36	204
251	238	3.47	233
299	158	3.53	153
401	128	3.47	123
501	168	3.82	163
801	253	5.37	246
1000	248	5.22	241
1249	240	5.31	233
1501	178	4.23	172

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4 **Table S2: Winter 30°E transect station information; regions - north of the Polar Front (NPF), south of**
5 **the Polar Front (SPF) and the subtropical zone (STZ), mixed layer depth (MLD) and mesopelagic depth-**
6 **weighted average Ba_{xs} concentrations.**

Station	Date (dd/mm/yr)	Latitude (°S)	Longitude (°E)	Zone	MLD (m)	Ba _{xs} (pmol L ⁻¹)
TM1	06/07/2017	58.5	30	SPF	156	249
TM2	06/07/2017	56	30	SPF	129	273
TM4	08/07/2017	50.5	30	SPF	97	346
TM5	09/07/2017	48	30	NPF	126	375
TM6	09/07/2017	45.5	30	NPF	215	329
TM7	10/07/2017	43	30	NPF	165	383
TM8	10/07/2017	41	30	STZ	118	192



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10 **Figure S1: Top panel is the latitudinal trend, south to north, left to right, of winter integrated mesopelagic Ba_{xs} stock concentrations**
11 **(black triangles). The bottom panel is the latitudinal trend of the corresponding annually integrated remotely sensed PP (black**
12 **circles). Sampling regions are overlaid in grey, namely SPF, NPF and STZ.**

15 **Table S3: Barium excess data used for the Southern Ocean (SO) compilation dataset, split into regions sampled during each study (south**
 16 **of the Polar Front (SPF), north of the Polar Front (NPF) and the subtropical zone (STZ)), the SO basin sampled, estimated POC**
 17 **remineralisation fluxes (POC_{rem}) using the Ba_{xs} method, integrated POC_{rem} is the POC flux multiplied by number of days from preceding**
 18 **September up to 1 month prior to sampling, $PP^{integrated}$ is the integrated remotely sensed PP multiplied by the number of days used for**
 19 **integrated POC_{rem} and % integrated POC_{rem} is the percentage integrated POC_{rem} to $PP^{integrated}$. No remotely sensed PP was available for**
 20 **studies preceding September 1997. *Particulate sample digestion methods did not use HF and thus may overestimate Ba_{xs} concentrations.**

Basin	Zone	Date	Latitude (°S)	Longitude (°E)	Ba_{xs} stock ($\mu\text{mol m}^{-2}$)	POC_{rem} ($\text{mg C m}^{-2} \text{d}^{-1}$)	Integrated POC_{rem} (mg C m^{-2})	$PP^{integrated}$ (mg C m^{-2})	% Integrated POC_{rem}	Reference
Indian (20°E - 145°E)	SPF	06/07/2017	58.5	30.0	224	32	8896	94226	9	
	SPF	06/07/2017	56.0	30.0	246	44	12232	89959	14	
	SPF	08/07/2017	50.5	30.0	311	78	21840	111498	20	
	NPF	09/07/2017	48.0	30.0	338	92	25852	121189	21	This study
	NPF	09/07/2017	45.5	30.0	296	70	19670	162823	12	
	NPF	10/07/2017	43.0	30.0	345	96	27072	229782	12	
	STZ	10/07/2017	41.0	30.0	173	6	1692	261424	1	
	SPF	01/11/2011	48.5	72.1	77	42	1302	3246	40	
	SPF	04/11/2011	48.7	72.0	72	35	1190	3505	34	
	SPF	12/11/2011	48.8	71.4	103	76	3192	4189	76	
	SPF	14/11/2011	48.7	72.6	89	58	2552	4693	54	Jacquet et al. (2015)
	SPF	16/11/2011	50.6	72.1	67	11	506	2957	17	
	SPF	18/11/2011	48.4	71.9	95	66	3168	6557	48	
	NPF	02/11/2011	48.4	75.0	60	20	640	3016	21	

NPF	07/11/2011	48.5	74.7	82	49	1813	3387	54	
SPF	20/01/2005	49.2	74.0	127	32	3552	20593	17	
SPF	24/01/2005	50.6	72.1	130	34	3910	15787	25	
SPF	26/01/2005	51.7	78.0	100	21	2457	18911	13	
SPF	29/01/2005	50.5	77.0	154	45	5400	20634	26	
SPF	30/01/2005	51.1	74.6	131	34	4114	13586	30	
SPF	03/02/2005	50.6	72.1	120	29	3625	20508	18	Jacquet et al. (2008a)
SPF	06/02/2005	51.7	78.0	160	48	6144	23831	26	
SPF	07/02/2005	52.4	75.6	145	41	5289	21603	25	
SPF	12/02/2005	50.6	72.1	111	25	3350	26108	13	
SPF	13/11/2001	53.7	142.0	88	15	645	6486	10	
SPF	16/11/2001	56.9	142.0	121	29	1334	6259	21	
SPF	20/11/2001	60.9	142.0	86	14	700	10680	7	
SPF	24/11/2001	63.9	142.0	79	12	648	10144	6	Cardinal et al. (2005)
SPF	05/12/2001	63.9	142.0	92	17	1105	15831	7	
SPF	07/12/2001	60.9	142.0	139	36	2412	18509	13	
NPF	03/11/2001	46.9	142.0	74	10	330	-	-	
NPF	07/11/2001	48.9	142.0	68	7	259	-	-	

NPF	09/11/2001	51.0	142.0	62	5	195	1621	12	
NPF	10/12/2001	51.0	142.0	59	4	280	10929	3	
NPF	19/01/1999	46.0	62.5	283	102	11220	80171	14	
NPF	25/01/1999	45.1	63.1	239	63	7308	86214	9	
NPF	28/01/1999	44.5	62.5	343	118	14042	87265	16	
STZ	31/01/1999	44.3	62.4	234	65	7930	92009	9	Jacquet et al. (2005)
STZ	02/02/1999	44.2	62.3	283	82	10168	93316	11	
STZ	07/02/1999	44.0	63.4	292	86	11094	90692	12	
STZ	13/02/1999	43.1	62.5	151	32	4320	100687	4	
SPF	19/03/1998	53.7	141.8	153	41	6929	82220	8	
SPF	22/03/1998	53.0	141.7	145	35	6020	81306	7	
NPF	07/03/1998	45.0	141.5	82	14	2198	100516	2	
NPF	10/03/1998	46.8	142.0	57	2	320	100374	0	Cardinal et al. (2001)
NPF	15/03/1998	49.5	141.8	96	20	3300	96739	3	
NPF	17/03/1998	51.0	141.8	127	30	5010	92570	5	
NPF	26/03/1998	50.9	142.8	94	17	2992	103327	3	
STZ	03/03/1998	42.0	141.9	87	15	2295	94660	2	
SPF	14/01/1987	56.5	63.2	95	43	5806	-	-	

	SPF	16/01/1987	59.5	69.9	70	31	4245	-	-	
	SPF	17/01/1987	61.8	76.3	84	38	5207	-	-	
	SPF	18/01/1987	64.2	84.0	52	21	2924	-	-	
	SPF	20/01/1987	66.0	67.3	37	14	1922	-	-	
	SPF	24/01/1987	63.8	42.0	67	29	4203	-	-	
	SPF	26/01/1987	65.2	32.0	47	19	2724	-	-	Dehairs et al. (1990)*
	SPF	27/01/1987	61.0	32.3	81	36	5341	-	-	
	SPF	28/01/1987	57.0	31.8	70	31	4555	-	-	
	SPF	29/01/1987	53.0	31.2	82	37	5485	-	-	
	NPF	01/02/1987	47.2	23.6	36	13	1985	-	-	
	STZ	05/02/1987	38.0	23.3	43	17	2615	-	-	
	STZ	07/02/1987	38.0	30.0	24	7	1093	-	-	
Indian (20°E - 145°E) & Pacific (145°E - 65°W)	SPF	01/02/2007	54.0	145.9	177	43	5314	61097	9	
	SPF	02/02/2007	54.0	146.1	167	38	4762	61864	8	
	SPF	03/02/2007	54.1	146.3	220	65	8100	62461	13	Jacquet et al. (2011)
	SPF	04/02/2007	54.5	146.1	258	84	10584	62828	17	
	SPF	05/02/2007	54.5	147.1	232	71	8992	61876	15	
	SPF	07/02/2007	50.9	148.7	140	44	5676	50368	11	

	NPF	20/01/2007	44.9	143.1	125	37	4107	60591	7	
	NPF	22/01/2007	46.3	140.6	94	22	2441	53982	5	
	NPF	26/01/2007	46.5	140.3	112	33	3875	57207	7	
	NPF	28/01/2007	46.6	140.6	94	22	2570	59415	4	
	NPF	08/02/2007	50.0	149.4	153	52	6760	52597	13	
	NPF	09/02/2007	48.1	151.2	198	73	9563	61995	15	
	NPF	11/02/2007	45.6	153.2	141	46	6065	86173	7	
	NPF	12/02/2007	45.5	153.4	148	49	6593	90826	7	
	NPF	14/02/2007	44.9	152.5	122	36	4896	97168	5	
	NPF	16/02/2007	45.6	153.7	130	40	5465	93136	6	
	STZ	19/02/2007	43.7	148.6	73	12	1692	114832	1	
Atlantic (65°W - 20°E)	SPF	11/03/2008	51.9	0.0	112	13	2155	66711	3	
	SPF	14/03/2008	55.2	0.0	132	23	3861	67327	6	
	NPF	27/02/2008	42.5	8.9	135	25	3740	114462	3	Planchon et al. (2013)
	NPF	01/03/2008	44.9	6.9	236	77	11658	85271	14	
	NPF	05/03/2008	47.5	4.4	145	30	4680	75250	6	
	NPF	07/03/2008	49.0	2.8	184	50	7900	66889	12	
		SPF	11/02/2004	50.0	2.0	324	78	10374	50310	21

SPF	22/02/2004	50.0	2.0	232	31	4464	59284	8	
SPF	23/02/2004	50.0	2.0	198	14	2030	60100	3	
SPF	04/03/2004	50.0	2.0	275	40	6200	69011	9	
SPF	09/03/2004	50.0	2.0	260	45	7200	71992	10	Jacquet et al. (2008b)
SPF	11/03/2004	50.0	2.0	353	92	14904	73184	20	
SPF	17/03/2004	50.0	2.0	360	96	16128	76760	21	
SPF	19/03/2004	50.0	2.0	292	61	10370	77953	13	
SPF	13/10/1992	56.5	-6.0	65	13	528	-	-	
SPF	14/10/1992	54.5	-6.0	54	7	293	-	-	
SPF	22/10/1992	56.1	-6.8	59	9	480	-	-	
SPF	25/10/1992	55.0	-6.0	69	14	779	-	-	
SPF	26/10/1992	53.0	-6.0	60	10	549	-	-	
SPF	27/10/1992	51.0	-6.0	73	16	923	-	-	Dehairs et al. (1997)*
SPF	29/10/1992	49.0	-6.0	76	18	1052	-	-	
SPF	06/11/1992	59.5	-6.0	77	19	1226	-	-	
SPF	12/11/1992	57.5	-6.0	59	9	681	-	-	
SPF	12/11/1992	57.5	-6.0	69	14	1023	-	-	
SPF	16/11/1992	53.0	-6.0	63	12	878	-	-	

SPF	17/11/1992	51.0	-6.0	76	25	1920	-	-	
SPF	19/11/1992	49.0	-6.0	94	27	2152	-	-	
SPF	23/11/1992	49.8	-6.0	77	19	1548	-	-	
NPF	18/10/1992	48.5	-6.0	101	31	1436	-	-	
NPF	30/10/1992	47.0	-6.0	77	18	1079	-	-	
NPF	21/11/1992	47.0	-6.0	86	23	1876	-	-	
NPF	22/11/1992	48.5	-6.0	86	23	1891	-	-	
SPF	26/11/1988	57.0	-49.0	78	32	2742	-	-	
SPF	27/11/1988	58.0	-48.9	21	6	503	-	-	
SPF	28/11/1988	59.0	-49.0	27	9	768	-	-	
SPF	28/11/1988	60.0	-49.0	26	8	721	-	-	
SPF	29/11/1988	61.0	-49.1	30	10	897	-	-	
SPF	30/11/1988	62.0	-49.0	27	9	784	-	-	Dehairs et al. (1991)*
SPF	02/12/1988	61.0	-49.0	31	11	979	-	-	
SPF	05/12/1988	59.0	-49.0	17	4	345	-	-	
SPF	08/12/1988	59.4	-48.7	15	3	252	-	-	
SPF	09/12/1988	59.4	-48.7	19	4	427	-	-	
SPF	10/12/1988	57.0	-49.0	57	24	2398	-	-	

SPF	11/12/1988	57.0	-48.7	50	20	2022	-	-
SPF	13/12/1988	57.0	-47.0	89	40	4146	-	-
SPF	13/12/1988	58.0	-47.0	37	14	1433	-	-
SPF	14/12/1988	59.0	-47.0	22	6	636	-	-
SPF	15/12/1988	60.0	-47.0	30	10	1081	-	-
SPF	16/12/1988	61.0	-47.0	44	17	1810	-	-
SPF	16/12/1988	61.5	-47.0	22	6	623	-	-
SPF	19/12/1988	60.9	-45.4	17	6	671	-	-
SPF	20/12/1988	50.0	-49.0	13	4	392	-	-
SPF	20/12/1988	59.5	-49.0	10	2	235	-	-
SPF	21/12/1988	60.0	-49.0	13	3	339	-	-
SPF	21/12/1988	60.5	-49.0	14	4	443	-	-
SPF	22/12/1988	61.0	-49.0	16	5	568	-	-
SPF	22/12/1988	61.5	-49.0	18	6	672	-	-
SPF	24/12/1988	62.1	-49.0	22	6	694	-	-
SPF	27/12/1988	57.0	-48.9	72	31	3597	-	-
SPF	28/12/1988	58.0	-49.0	47	18	2131	-	-
SPF	28/12/1988	59.0	-49.0	38	13	1585	-	-

	SPF	29/12/1988	60.0	-49.0	22	5	640	-	-
	SPF	30/12/1988	61.0	-49.0	24	7	815	-	-
	SPF	31/12/1988	61.7	-48.8	11	0	0	-	-

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Table S4: Least squares regression statistics for correlations between mesopelagic Ba_{xs} stock and temporally integrated remotely sensed PP of the SO compilation data for all tested timescales between the preceding September and 1 month prior to sampling (Sept - T1) where the T-value is the number of months prior to sampling. Sept - T1 regressions considered integrated PP from Sept 2016 to June 2017 and T1 - T2 considered PP from May 2017 to June 2017, for this study (July 2017). For a study conducted in March 1998, Sept - T1 considered PP from September 1997 to February 1998 and T1 - T2 considered PP from January 1998 to February 1998.

Zones	SPF			NPF			STZ		
Time scales	R ²	p-value	n	R ²	p-value	n	R ²	p-value	n
Sept - T1	0.55	6×10^{-8}	39	0.42	9×10^{-5}	31	0.53	0.10	6
Sept - T2	0.30	2×10^{-3}	29	0.34	2×10^{-3}	26	0.93	2×10^{-3}	6
Sept - T3	0.19	0.02	30	0.37	1×10^{-3}	25	0.37	0.20	6
Sept - T4	0.09	0.13	26	0.67	3×10^{-5}	18	0.12	0.57	5
T1-T2	0.51	2×10^{-7}	40	0.01	0.60	30	0.06	0.63	6
T1-T3	0.33	8×10^{-4}	30	0.11	0.11	25	0.16	0.43	6
T1-T4	0.31	2×10^{-3}	28	0.16	0.05	24	0.45	0.14	6
T2-T3	0.29	2×10^{-3}	30	0.15	0.05	26	0.57	0.08	6
T2-T4	0.25	6×10^{-3}	28	0.10	0.13	25	0.76	0.02	6
T3-T4	0.14	0.04	30	0.00	0.77	25	0.56	0.09	6

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