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Supplement of

Stratification of surface waters during the last glacial millennial climatic events: a key factor in subsurface and deep-water mass dynamics

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Why interpreting the reconstructed planktonic foraminiferal temperature signal as relative subsurface temperature variations is coherent in our study area?

In the present study, we reconstruct oceanic temperatures by applying a transfer function to planktonic foraminifera assemblages. This transfer function uses a modern database where annual and seasonal oceanic temperatures are extracted at 10 meters water depth. In such a configuration, the reconstructed temperatures are, or should be a priori, assumed to represent sea-surface temperatures (SST).

However, the comparison of our foraminifera-derived temperature (F-Temp) signals with our dinocyst-derived SST signals (reconstructed by applying a similar transfer function to dinocyst assemblages) shows strong discrepancies. Studies dealing with SST reconstructions obtained through different methods (e.g. Mg/Ca on planktonic foraminifera shells, relative abundance of planktonic foraminifera index species, alkenone index UK'37, transfer functions applied to assemblages of planktonic foraminifera, dinocysts, diatoms, coccoliths, etc.) are generally also confronted to similar discrepancies (e.g. Mazaud et al., 2002; Sicre et al., 2005; de Vernal et al., 2005, 2006; Peck et al., 2008; Penaud et al., 2011). To explain it, the authors usually call for differences in growth season and/or in depth habitat of the associated organisms, and/or for interannual variability, and/or for allochthonous advection. In the case of dinocyst-derived versus planktonic foraminifera-derived temperature reconstructions, many studies have mainly attributed these discrepancies to changes in depth habitat (e.g. de Vernal et al., 2005, 2006; Penaud et al., 2011).

In our case, such an explanation is strongly coherent from an ecological point of view, given that:

1) While dinoflagellates, as part of the phytoplankton, are restricted to the photic layer (Sarjeant, 1974), heterotrophic planktonic foraminifera may live deeper (e.g. Schiebel et al., 2001). This is particularly true for the main species composing our foraminiferal assemblages since they do not bear any symbiont.

2) Our dinocyst-derived SSS (sea-surface salinity) records indicate the presence of a low saline surface layer throughout the last glacial period (mean of 31 and 32 psu for summer and winter SSS respectively). However, the planktonic foraminifera species identified in our assemblages (Table S1) barely tolerate such salinities (Tolderlund and Bé, 1971).

Hence, given the ecological tolerances of the identified planktonic foraminifera species, it seems consistent to relate planktonic foraminifera assemblages to a depth habitat deeper than the one of dinocysts.

However, as SST in the modern planktonic foraminifera database are extracted at 10 m water depth, it is a priori incoherent to interpret the reconstructed F-Temp as subsurface temperatures. Nonetheless, according to previous works focused on transfer functions (using the modern analog technique) applied to planktonic foraminifera assemblages, it seems reasonable to interpret the F-Temp signals as relative variations of subsurface temperatures in our study area.

Indeed, for transfer functions sensu lato, the reference living-depth of foraminifera to consider in modern SST training sets is really problematic and its definition not trivial. Numerous tests were previously done on this question. Among them, Pflaumann et al. (1996) have demonstrated that such a consideration does not provide significant differences in the reconstructed F-Temp. Telford et al.

(2013) showed that "*For cores north of 25°N, the* [paleo]*reconstructions from different depths and seasons resemble one another, with an offset*", implying that **even if we have chosen another extraction depth for SST, the relative variations of our signals would be very similar**.

Furthermore, even if Telford et al. (2013) evidenced that for sites in the North Atlantic drift (including the nearby site NA87-22; cf. page 862) paleoreconstructions at all depth are statistically significant, he also argue that "*the most ecologically relevant depth varies in space and time, and the assemblages will probably integrate the communities from several depths and seasons, so selecting a more appropriate fixed depth for temperature reconstructions for each location is probably not trivial and does not completely circumvent the problem*.". This latter statement is also supported by Adloff et al. (2011): "*The currently used technique to reconstruct temperature from planktonic foraminifera* [by extracting SST averaged over a depth interval depending on the living depth of the foraminifera species identified] *is likely inadequate for time periods when the vertical temperature gradient was different from today*". Hence, it appears that **there is no valuable reason to define a depth or a depth section (for the extraction of SST in the modern database) as more appropriate than another one, particularly because it must have evolved through time**.

Therefore, in our study area, it seems coherent to interpret the F-Temp signals – reconstructed from modern SST extracted at 10 m water depth – as relative variations of "subsurface" temperatures. The "subsurface" depth range is however difficult to define, but we can reasonably suppose that F-Temp signals are integrated over the potential depth range of the whole assemblage (i.e. 0-300 meters water depth here).

Such an assumption allows for the conciliation of our phytoplanktonic-derived versus zooplanktonic-derived signals, i.e. the reconstructed hydrological parameters as well as the environmental information carried by the respective assemblages (characterized by communities which ecologically do not sound as belonging to a common environment / water mass). Thus, it allows us to provide a constructive view of what can be interpreted from the strong difference calculated.

Table S1: raw planktonic foraminifera counts

Depth (cm)	Age (ka cal BP) - age model from Zumaque et al., 20102	*N. pachyderma*	*N. incompta*	*G. bulloides*	*G. quinqueloba*	*G. scitula*	*G. glutinata*	*G. inflata*	*H. aequilateralis*	*G. falconensis*	*G. hirsuta*	*G. truncatulinoides dextre*	*G. truncatulinoides senestre*	*O. universa*	*T. humilis*	*G. rubescens*	*G. ruber alba*	*G. ruber rosea*	*G. conglobatus*	*G. tenellus*	*G. calida*	*G. crassaformis*	*H. pelagica*	*G. digitata*	*G. trilobus*	*G. sacculiferus*	*N. dutertrei*	*G. menardii*	*P. obliquiloculata*	*G. tumida*	*S. dehiscens*	*C. nitida*	*T. hexagona*	*G. parkerae*	*G. theyeri*	*Praeorbulina*	*O. suturalis*	*O. bilobata*	*G. conglomerata*	*G. uvula*	*G. anfracta*	*H. adamsi*	Undetermined	Total
300	12155	107	66	100	58	8	24	5								1																											2	371
310	12179	116	62	84	58	2	32	3		3						1	1																												362
320	12204	125	69	82	42	7	23	6		2							2																							1			1	360
330	12228	143	67	74	41	7	19	7																																1	1		1	361
340	12253	122	73	71	38	8	33	4								3																								1			2	355
350	12277	85	98	100	30	10	30	2																																			2	357
360	12302	112	86	94	38	1	32	2																																			2	367
370	12326	129	73	100	21	2	37	5								1	2																							2			1	373
380	12351	136	84	77	28	3	37	2		2																														1			1	371
390	12375	154	65	59	38	2	23	7		1						1																											1	351
400	12400	185	56	55	23	4	20	8																																			1	352
410	12866	171	57	64	53	3	22	12		1																																	1	384
420	13332	151	64	97	27	1	28	7								1																											2	378
430	13799	254	30	43	16	2	11									1	1																										2	360
440	14265	245	52	41	21	4	10	1									1																											375
450	14731	314	20	22	13	1	4	1																																				375
460	15198	341	11	2	7		1										1																											363
470	15664	342	5	1	11																																							359
480	16130	334	10	8	3		1					1																																357
490	16597	348	8	10	12		4																																				1	383
500	17063	350	10	4	5		2																																				1	372
510	17529	355	8	8	5		1																																					377
520	17610	319	18	20	6		7									3																												373
530	17690	286	7	27	15		15									1																												351
540	17771	261	7	12	24		52																																				4	360
550	17851	276	6	19	16		41									2																												360
560	17932	261	14	32	23		41									2																												373
570	18012	260	2	32	29		51																																					374
580	18092	288	7	17	18		31																																				1	362
590	18140	295	12	18	34		26																																					385

Depth (cm)	Age (ka cal BP) - age model from Zumaque et al., 20102	*N. pachyderma*	*N. incompta*	*G. bulloides*	*G. quinqueloba*	*G. scitula*	*G. glutinata*	*G. inflata*	*H. aequilateralis*	*G. falconensis*	*G. hirsuta*	*G. truncatulinoides dextre*	*G. truncatulinoides senestre*	*O. universa*	*T. humilis*	*G. rubescens*	*G. ruber alba*	*G. ruber rosea*	*G. conglobatus*	*G. tenellus*	*G. calida*	*G. crassaformis*	*H. pelagica*	*G. digitata*	*G. trilobus*	*G. sacculiferus*	*N. dutertrei*	*G. menardii*	*P. obliquiloculata*	*G. tumida*	*S. dehiscens*	*C. nitida*	*T. hexagona*	*G. parkerae*	*G. theyeri*	*Praeorbulina*	*O. suturalis*	*O. bilobata*	*G. conglomerata*	*G. uvula*	*G. anfracta*	*H. adamsi*	Undetermined	Total
600	18188	256	8	35	14		45																																					358
610	18236	265	6	23	8		49																																					351
620	18284	305	14	26	11		40																																				1	397
630	18332	261	8	33	7		50																																					359
640	18380	280	4	23	41		43																																				1	392
650	18427	287	5	20	25		37																																					374
660	18612	317	5	16	21		33																																					392
670	18797	304	7	16	19		36																																				1	383
680	18982	299	6	15	10		31																																				1	362
690	19167	290	6	20	27		37																																				2	382
700	19351	291	6	19	16		42																																				1	375
710	19536	297	2	24	32	1	52																																					408
720	19721	257	8	31	24		40																																				1	361
730	19906	348	12	29	19		45																																					453
740	20091	260	13	36	17		40																																				2	368
750	20275	281	4	15	10		42																																					352
760	20460	249	11	30	26		43																																				2	361
770	20645	222	5	37	39		59																																					362
780	20830	319	8	12	17		30																																				2	388
790	20984	277	6	24	27		22																																					356
800	21138	239	5	26	33	1	45																																				1	350
810	21292	239	4	22	40		47																																					352
820	21446	237	7	30	38		51																																					363
830	21600	262	5	24	19		43																																					353
840	21754	274	6	14	24		36																																				2	356
850	21908	275	6	15	19		39																																				2	356
860	22062	265	11	25	21		50																																				1	373
870	22217	278	3	20	16		39																																					356
880	22371	306	3	22	30		54																																					415
890	22525	315	4	39	20		36																																				1	415
900	22679	305	8	19	32		44																																					408
910	22833	365	11	53	25		81																																				3	538
920	22987	308	5	24	9		19																																					365
930	23141	307		23	12		23																																				1	366
940	23295	302	6	14	15		16																																					353
950	23449	367		6	20		2																																					395
960	23603	342	5	4	58		1																																				1	411
970	23757	352	6	3	17		3																																					381
980	23911	293	6	19	53	5	9																																				1	386
990	24066	222	7	38	101	3	3	1																																			1	376

Depth (cm)	Age (ka cal BP) - age model from Zumaque et al., 20102	*N. pachyderma*	*N. incompta*	*G. bulloides*	*G. quinquloba*	*G. scitula*	*G. glutinata*	*G. inflata*	*H. aequilateralis*	*G. falconensis*	*G. hirsuta*	*G. truncatulinoides dextre*	*G. truncatulinoides senestre*	*O. universa*	*T. humilis*	*G. rubescens*	*G. ruber alba*	*G. ruber rosea*	*G. conglobatus*	*G. tenellus*	*G. calida*	*G. crassaformis*	*H. pelagica*	*G. digitata*	*G. trilobus*	*G. sacculiferus*	*N. dutertrei*	*G. menardii*	*P. obliquiloculata*	*G. tumida*	*S. dehiscens*	*C. nitida*	*T. hexagona*	*G. parkerae*	*G. theyeri*	*Praeorbulina*	*O. suturalis*	*O. bilobata*	*G. conglomerata*	*G. uvula*	*G. anfracta*	*H. adamsi*	Undetermined	Total
1000	24220	309	5	4	32		3																																				2	355
1010	24374	320	4	0	37																																						1	362
1020	24528	308	4	7	69	4	3																																				2	397
1030	24682	152	13	96	72	7	12																																				5	357
1040	24836	117	22	161	63	9	9																																				1	382
1050	24990	330	7	1	21																																						2	361
1060	25144	355	8	10	15																																						1	389
1070	25298	337	5	2	25																																						1	370
1080	25452	364	3	2	14																																							383
1090	25606	346	4	3	33	1	2																																				1	390
1100	25760	321	3		30																																							354
1110	25914	359	4	5	23																																						4	395
1120	26069	348	1		8																																							357
1130	26223	395	2	1	20		3																																					421
1140	26377	375	3		29																																							407
1150	26531	308	6	4	47			1																																				366
1160	26685	302	3	2	47		2																																				1	357
1170	26839	307	4	4	37																																							352
1180	26993	360	6	3	19																																							388
1190	27066	367	4	2	17																																							390
1200	27139	311	7	6	38																																						1	363
1210	27212	285	2	10	69																																						1	367
1220	27284	304	1	10	41	2	3																																				2	363
1230	27357	323	5	5	25	2	1																																					361
1240	27430	276	4	15	43	5	7	1																																			1	352
1250	27516	131	16	79	98	21	13	1																																			4	363
1260	27601	157	22	70	117	18	13																																				1	398
1270	27687	180	15	59	79	5	14																																				1	353
1280	27992	325	14	10	21																																							370
1290	28271	313	7	15	20	2	7																																					364
1300	28550	141	11	97	90	6	21																																				1	367
1310	28605	94	34	95	113	19	29																																				3	387
1320	28659	85	25	95	102	21	31																																					359
1330	28714	109	41	106	63	18	29																																				1	367
1340	28768	174	23	102	58	7	29	1																																			2	396
1350	28823	269	11	44	24	1	18																																				1	368
1360	29037	347	8	6	15		6																																					382
1370	29410	286	7	30	10		20																																				1	354
1380	29784	240	7	28	32		51																																					358
1390	30158	231	4	23	38		68																																				2	366

Depth (cm)	Age (ka cal BP) - age model from Zumaque et al., 20102	*N. pachyderma*	*N. incompta*	*G. bulloides*	*G. quinquloba*	*G. scitula*	*G. glutinata*	*G. inflata*	*H. aequilateralis*	*G. falconensis*	*G. hirsuta*	*G. truncatulinoides dextre*	*G. truncatulinoides senestre*	*O. universa*	*T. humilis*	*G. rubescens*	*G. ruber alba*	*G. ruber rosea*	*G. conglobatus*	*G. tenellus*	*G. calida*	*G. crassaformis*	*H. pelagica*	*G. digitata*	*G. trilobus*	*G. sacculiferus*	*N. dutertrei*	*G. menardii*	*P. obliquiloculata*	*G. tumida*	*S. dehiscens*	*C. nitida*	*T. hexagona*	*G. parkerae*	*G. theyeri*	*Praeorbulina*	*O. suturalis*	*O. bilobata*	*G. conglomerata*	*G. uvula*	*G. anfracta*	*H. adamsi*	Undetermined	Total
1400	30531	209	7	70	86	4	15																																				1	392
1410	30905	285	4	40	18		38																																				1	386
1420	31278	330	3	4	13		5																																				1	356
1430	31652	306	11	16	26		3																																				4	366
1440	31718	317	4	10	25	1	2																																					359
1450	31784	343	5	14	14		1																																				1	378
1460	31851	291	4	26	55		1																																					377
1470	31917	181	11	71	100	2	13																																				1	379
1480	32002	111	5	101	130	7	13																																				2	369
1490	32106	145	7	90	107	4	16																																				3	372
1500	32210	137	6	126	64	2	13	1																																			2	351
1510	32315	272	7	62	43	6	8																																				1	399
1520	32419	321	5	31	19	1	7																																				2	386
1530	32685	351	5	8	7																																							371
1540	33021	332	4	18	16		6																																					376
1550	33304	302	7	21	38	4	10																																				2	384
1560	33374	194	17	85	76	8	23																																				1	404
1570	33444	166	13	116	78	11	27																																				1	412
1580	33515	132	13	175	49	6	16																																				1	392
1590	33585	185	13	89	48	8	43																																				1	387
1600	33655	217	5	87	18	2	29	1																																				359
1610	33806	293	5	41	12		28																																				6	385
1620	34037	337	3	8	3		10																																				1	362
1630	34268	296	4	28	18		15																																				3	364
1640	34499	267	6	39	25		27																																				5	369
1650	34730	177	11	65	49	2	55																																				1	360
1660	34845	188	9	70	51	1	53																																				2	374
1670	34960	217	13	69	51	6	32																																				4	392
1680	35074	173	18	93	53	2	28																																				2	369
1690	35189	164	12	131	48	5	20																																				1	381
1700	35304	237	9	83	42	2	15																																				2	390
1710	35419	290	9	44	23	2	18	1																																			1	388
1720	35663	351	6	10	7		2																																					376
1730	35922	344	15	6	5		1																																					371
1740	36181	359	5	19	14		9																																					406
1750	36440	293	5	26	25	1	30																																				1	381
1760	36634	197	7	46	56	1	43																																				3	353
1770	36762	293	4	20	26		14																																					357
1780	36890	276	5	31	36	3	8																																					359
1790	37018	255	6	69	50	2	9																																				1	392

Depth (cm)	Age (ka cal BP) - age model from Zumaque et al., 20102	*N. pachyderma*	*N. incompta*	*G. bulloides*	*G. quinqueloba*	*G. scitula*	*G. glutinata*	*G. inflata*	*H. aequilateralis*	*G. falconensis*	*G. hirsuta*	*G. truncatulinoides dextre*	*G. truncatulinoides senestre*	*O. universa*	*T. humilis*	*G. rubescens*	*G. ruber alba*	*G. ruber rosea*	*G. conglobatus*	*G. tenellus*	*G. calida*	*G. crassaformis*	*H. pelagica*	*G. digitata*	*G. trilobus*	*G. sacculiferus*	*N. dutertrei*	*G. menardii*	*P. obliquiloculata*	*G. tumida*	*S. dehiscens*	*C. nitida*	*T. hexagona*	*G. parkerae*	*G. theyeri*	*Praeorbulina*	*O. suturalis*	*O. bilobata*	*G. conglomerata*	*G. uvula*	*G. anfracta*	*H. adamsi*	Undetermined	Total
1800	37146	170	18	70	83	4	26																																					371
1810	37274	168	22	79	91	16	13	1																																			1	391
1820	37402	92	36	96	123	24	25																																					396
1830	37530	157	15	94	110	25	15	1																																				417
1840	37658	151	16	82	70	18	16																																				2	355
1850	37786	175	12	84	59	24	23																																				1	378
1860	37914	259	9	73	38	15	8																																					402
1870	38042	270	19	53	15	11	8																																					376
1880	38170	330	5	16	8	1	4																																				1	365
1890	38498	371	3	6	5		2																																					387
1900	38826	350	5		4																																							359
1910	39154	362	3	5	7		4																																					381
1920	39482	382	3	4	10																																						1	400
1930	39810	298	6	21	27	2																																						354
1940	39910	184	8	114	54	7	14																																					381
1950	40010	224	6	127	53	7	10																																					427
1960	40110	295	2	42	46		4																																					389
1970	40196	312	3	20	9		7																																					351
1980	40281	318	4	22	12																																							356
1990	40367	373	6	11	5		1																																					396
2000	40453	328	5	14	16	1	2																																					366
2010	40539	327	4	15	23		6																																					375
2020	40624	324	5	23	17	2	3																																					374
2030	40710	292	4	32	42		15																																				1	386
2040	40827	203	10	107	21	5	26																																				1	373
2050	40943	154	17	75	119	3	27																																					395
2060	41060	184	8	76	71	6	24																																					369
2070	41177	163	13	71	58	5	47																																				2	359
2080	41293	194	14	105	43	3	25																																					384
2090	41410	214	16	83	49	1	51																																					414

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