Supplemental Information For:

Widespread occurrence of distinct alkenones from Group I haptophytes in freshwater lakes: Implications for paleotemperature and paleoenvironmental reconstructions

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Table S1. Lakes and samples analyzed in this study with lake morphometry, water chemistry, LCA distribution parameters and mean annual climate conditions.

Sample ID	Lake Name	Basin Type	Lat.	Long.	Sample Type	Section Depth (cm)§	pH	Salinity classification	Salinity (psu)	Max Depth (m)	LCA Occurrence/ Distribution	U^{K}_{37}	RIK_{37}	RIK_{38E}	C_{37}/C_{38}	$\%C_{37:4}$	MAAT (°C)	MAP (mm)
G-01	Baejarvotn[1,2]	ND	65.73	-21.43	core	9.5	7.4	fresh	0	ND	Group I	-0.27	0.49	0.33	1.22	35.09	2.4	786
G-02	Breiter Luzin[3]	glacial	53.35	13.46	SS		8.7	fresh	0.2	58.3	Group I	-0.45	0.64	0.48	1.53	49.50	8.2	574
G-03	Erlongwan	maar	42.30	126.38	SS		8.7	fresh	0.02	36	Group I	-0.35	0.56	0.27	1.06	45.35	2.6	855
G-04	Étang des Vallées[4]	reservoir	48.69	1.92	SS		7.2	fresh	0	1.5	**Group I†**	-0.32	0.60	0.57	1.54	36.47	10.4	642
G-05	Feldberger Haussee[3]	glacial	53.35	13.45	SS		8.9	fresh	0.2	12.5	Group I	-0.40	0.63	0.40	1.19	46.69	8.1	577
G-06	Hajeren[5]	glacial	79.26	11.52	core	7.25	6.6	fresh	0	19.5	Group I	-0.42	0.54	0.00	1.02	49.09	-5.6	370
G-07	Hakluytvatnet[5]	glacial	79.77	10.74	core	4	5.9	fresh	0	5	Group I	-0.60	0.49	0.15	1.03	62.18	-6.2	363
G-08	Hakluytvatnet[5]	glacial	79.77	10.74	core	9.5	5.9	fresh	0	5	Group I	-0.62	0.51	0.11	0.94	63.19	-6.2	363
G-09	Ichi-no-Megata[6]	maar	39.95	139.74	SPM		7.2	fresh	0	45.1	Group I	-0.47	0.60	0.33	1.38	52.70	10.9	1657
G-10	Ichi-no-Megata[6]	maar	39.95	139.74	SPM		7.2	fresh	0	45.1	Group I	-0.48	0.59	0.44	3.33	53.61	10.9	1657
G-11	Lake Toyoni[7]	slide-dammed	42.09	143.27	SS		7.2	fresh	0	19	**Group I†**	-0.48	0.54	0.17	0.84	51.06	5.4	1313
G-12	Schmaler Luzin[3]	glacial	53.32	13.44	SS		8.5	fresh	0.2	33.5	Group I	-0.42	0.63	0.45	1.39	46.02	8.1	581
G-13	Skufnavotn[1]	ND	65.89	-22.12	core	20	ND	fresh*	ND	ND	Group I	-0.45	0.48	0.15	0.69	49.24	0.5	924
G-14	Svartagilsvatn[1]	ND	65.85	-21.88	core	5	ND	fresh*	ND	ND	Group I	-0.59	0.55	0.08	0.75	63.39	0.5	904
G-15	Upper Murray Lake[8]	glacial	81.33	-69.50	core	0.75	8.2	fresh	0.05	83	**Group I†**	-0.55	0.57	0.30	0.88	59.83	-17.3	125
G-16	Vatnsdalsvatn[1,9]	ND	65.61	-23.11	core	2	6.7	fresh	ND	ND	Group I	-0.63	0.58	0.16	0.94	62.91	3.7	986
G-17	Vestre Gisholtsvatn[1,2]	ND	63.95	-20.52	core	6.5	7.7	fresh	ND	ND	Group I	-0.57	0.60	0.23	0.97	57.29	4.8	1190
G-18	Vikvatnet[10]	glacial	68.20	13.58	ST		7.0	fresh	0	31	**Group I†**	-0.25	0.60	0.48	1.07	32.10	4.6	1353
G-19	Wudaliangchi[11]	volcanic	48.73	126.17	SS		7.8	fresh	0.166	9.2	Group I	-0.49	0.60	0.15	1.08	55.00	0.2	516
G-20	Xianhe	volcanic	47.36	120.45	SS		7.8	fresh	0.03	14	Group I	-0.39	0.54	0.25	0.98	45.33	-3.0	486
G-21	Khirgis Nuur	intermountain	49.20	93.40	SS		9.4	mesohaline	7.9	75	Group II	0.20	1.00	1.00	3.43	0.00	-2.0	145
G-22	Yarkov Basin of Chany Lake[12]	deflation	54.94	77.98	core	4.5	7.2	mesohaline	6-11	4	Group II	0.25	1.00	1.00	0.98	0.00	0.5	356
G-23	Yarkov Basin of Chany Lake[12]	deflation	54.94	77.98	core	32.5	7.2	mesohaline	6-11	4	Mixed I/II	-0.18	0.76	0.52	1.23	34.11	0.5	356
G-24	Airag Nuur	intermountain	48.90	93.47	SS		9.6	mesohaline	4.5	10	ND						-1.3	127
G-25	Baejarvotn[1,2]	ND	65.73	-21.43	core	5	7.4	fresh	ND	ND	ND						2.4	786
G-26	Haukadalsvatn[1,9]	ND	65.05	-21.63	core	1	7.7	fresh	ND	ND	ND						3.6	803
G-27	Hestvatn[1,13]	reservoir	64.01	-20.72	core	3	7.8	fresh	ND	ND	ND						4.7	1128

G-28	Hestvatn[1,13]	reservoir	64.01	-20.72	core	1	7.8	fresh	ND	ND	ND	4.7	1128
G-29	Hvitarvatn[1,14]	glacial	64.60	-19.83	core	8.5	7.5	fresh	ND	ND	ND	2.2	1167
G-30	Hvitarvatn[1,14]	glacial	64.60	-19.83	core	9.5	7.5	fresh	ND	ND	ND	2.2	1167
G-31	Kotuvatn[1]	ND	66.06	-21.87	core	12	ND	fresh*	ND	ND	ND	1.1	845
G-32	Lake Mongco	ND	29.53	98.84	core	0.5	ND	fresh	ND	ND	ND	1.9	545
G-33	Laugabolsvatn[1,9]	ND	65.98	-22.67	core	4	7.6	fresh	ND	ND	ND	2.9	883
G-34	Longhupao[11]	ND	46.72	124.38	SS		8.4	fresh	0.5	3.5	ND	3.9	418
G-35	Small Chany Lake[12]	deflation	54.55	77.98	core	40.5	8.9	oligohaline	1.7	3.5	ND	0.8	335
G-36	Small Chany Lake[12]	deflation	54.55	77.98	core	0.5	8.9	oligohaline	1.7	3.5	ND	0.8	335
G-37	Wuliangsuhai[11]	ND	40.82	108.85	SS		7.8	oligohaline	1.26	2.5	ND	6.9	238

* Lakes assumed to be fresh based on adjacent freshwater lakes, climate, and bedrock (Langdon et al., 2008; Karst-Riddoch et al., 2009; Florian, 2016)
† Lake with phylogenetically confirmed Group I LCA producer
§ Section depth for core samples = cmblf for G-06—G-08, G-15, G-22, G23, G-32, G-35, G-36. Approximates cmblf for all other core samples.
SS = Surface sediment
SPM = Suspended particulate matter
ST = Sediment trap
ND = Not detected (for LCAs) or No data (for environmental data)
MAAT = Mean annual air temperature
MAP = Mean annual precipitation

[1] LacCore (National Lacustrine Core Facility), Department of Earth Sciences, University of Minnesota, Twin Cities
[2] Florian, 2016
[3] Zink et al., 2001; Nixdorf et al., 2004
[4] Simon et al., 2013; 2015
[5] van der Bilt et al., 2016
[6] Sato et al., 1986; Yamada et al., 2010
[7] McColl, 2016: Hada and Kusuki, 1938
[8] Besonen et al., 2008
[9] Langdon et al., 2008
[10] D'Andrea et al., 2016
[11] Chu et al., 2005
[12] Song, 2016
[13] Karst-Riddoch et al., 2009
[14] Black, 2008

Table S2. Samples, LCA parameters, and climate data used for temperature regressions.[1]

Lake Name	Köppen Climate Classification	Köppen Notation	U^{K}_{37}	R3b	U^{K}_{38Me}	MAAT (°C)	MTSI (°C)	MTWQ (°C)	LCA Data Source
Hakluytvatnet	Tundra	ET	-0.60	0.47	-0.28	-6.2	-2.8	2.7	This study
Upper Murray	Tundra	ET	-0.55	0.41	-0.27	-17.3	-1.975	0.9	This study
E5	Tundra	ET	-0.53	0.35	-0.25	-11.6	-0.25	7.8	Longo et al., 2016
Fog1	Tundra	ET	-0.59	0.40	-0.12	-11.5	-0.15	7.8	Longo et al., 2016
SS6	Tundra	ET	-0.68	ND	ND	-5.4	-4.35	7.5	D'Andrea et al., 2005
BrayaSo	Tundra	ET	-0.61	ND	ND	-5.4	-4.35	7.5	D'Andrea et al., 2005
HundeSo	Tundra	ET	-0.66	ND	ND	-5.4	-4.35	7.5	D'Andrea et al., 2005
LimnaeaSo	Tundra	ET	-0.61	ND	ND	-5.4	-4.35	7.5	D'Andrea et al., 2005
Lake E	Tundra	ET	-0.60	ND	ND	-5.4	-4.35	7.5	D'Andrea et al., 2005
Xianhe	Subarctic	Dwc	-0.39	0.39	-0.14	-3	1.6	14.5	This study
INI-004	Subarctic	Dfc	-0.45	0.32	-0.07	-12.3	-1.775	7.6	Longo et al., 2016
Toolik	Subarctic	Dfc	-0.54	0.38	-0.16	-11.4	0.1	8.2	Longo et al., 2016
Galbraith	Subarctic	Dfc	-0.48	0.40	ND	-11.3	0.225	8.1	Longo et al., 2016
S6	Subarctic	Dfc	-0.63	0.38	-0.15	-11.4	-0.025	8.1	Longo et al., 2016
Fishing	Subarctic	Dfc	-0.53	0.31	-0.24	0.5	0.5	15.9	Longo et al., 2016
Lenore	Subarctic	Dfc	-0.48	0.29	-0.13	0.8	1.1	16.2	Longo et al., 2016
Toyoni	Humid Continental	Dfb	-0.48	0.40	-0.23	5.4	0.35	15.8	This study
Erlongwan	Humid Continental	Dwa	-0.35	0.46	-0.01	2.6	-0.575	18.9	This study
Wudaliangchi	Humid Continental	Dwb	-0.49	0.37	-0.25	0.2	-3.4	18.7	This study
Schmaler Luzin	Humid Continental	Dfb	-0.42	0.57	-0.17	8.1	2	16.7	This study
Feldberger Haussee	Humid Continental	Dfb	-0.40	0.52	-0.08	8.1	2.025	16.7	This study
Breiter Luzin	Humid Continental	Dfb	-0.45	0.62	-0.16	8.2	2.05	16.7	This study
Étang des Vallées	Temperate Oceanic	Cfb	-0.32	0.70	0.02	10.4	5.75	17.3	This study

[1] Samples used were restricted to surface sediments or core samples with verifiable sediment depths (cmblf) of 0 to 5 cm.
ND = No Data. (LCA measurements made without separation of tri-unsaturated isomers).

Table S3. Alkenone distribution synthesis data

Phylotype	Species	RIK_{37}		RIK_{38E}		C_{37}/C_{38}		$\%C_{37:4}$	
		mean	*range*	*mean*	*range*	*mean*	*range*	*mean*	*range*
Group I	-	0.56	(0.53-0.6)	0.30	(0.17-0.57)	1.16	(0.84-1.54)	53.87	(36.47-65)
Group II	*I. GalbanaCCMP1323*	1.00	-	0.99	(0.98-1)	3.17	(2.56-3.79)	17.93	(6.35-29.52)
	I. GalbanaUTEX	1.00	-	1.00	-	7.68	(3.23-13.58)	0.00	-
	R. Lamellosa	1.00	-	0.90	(0.75-1)	2.85	(1.3-4.8)	48.73	(6.3-80.73)
	T. Lutea	1.00	-	1.00	-	4.22	(2.79-5.71)	0.37	(0-2.23)
Group III	*E. huxleyi*	1.00	-	1.00	-	1.53	(0.29-7.48)	1.13	(0-10.39)
	G. Oceanica	1.00	-	1.00	-	1.06	(0.59-1.66)	0.46	(0-4.66)

[1]References to data sources are outlined in section 2.4. Data are plotted in Figure 3.

Table S4. Sediment trap data from Toolik Lake and Lake E5.

Year	Lake	Deployment date	Collection date	C_{37} flux (µg/m^2/d)[1]	U^K_{37} [1]
2013	Toolik	20-Jun	2-Jul	11.75 (0.02)	-0.59 (0.004)
		2-Jul	26-Jul	3.64 (0.79)	-0.54 (0.013)
		26-Jul	10-Aug	ND	ND
2014	Toolik	15-May	1-Jul	0.44 (0.03)	-0.55 (0.0001)
		1-Jul	18-Jul	ND	ND
		18-Jul	10-Aug	ND	ND
		10-Aug	29-Aug	ND	ND
		29-Aug	20-Sep	ND	ND
2014	E5	16-May	1-Jul	1.52 (0.27)	-0.52 (0.026)
		1-Jul	23-Jul	ND	ND
		23-Jul	6-Aug	ND	ND
		6-Aug	22-Sep	ND	ND

[1]LCA measurements are represented as the mean of triplicate or duplicate samples with standard deviation shown in parenthesis.
ND = No Data. (LCAs not detected in the samples).

Table S5. Fractional abundances of LCAs analyzed in this study.

Sample ID	$C_{37:4}$	$C_{37:3a}$	$C_{37:3b}$	$C_{37:2}$	$C_{38:4}$Et	$C_{38:3a}$Et	$C_{38:3b}$Et	$C_{38:2}$Et	$C_{38:4}$Me	$C_{38:3a}$Me	$C_{38:3b}$Me	$C_{38:2}$Me	$C_{39:4}$Et	$C_{39:3a}$Et	$C_{39:3b}$Et	$C_{39:2}$Et
G-01	0.181	0.143	0.149	0.043	0.118	0.052	0.109	0.044	0.023	0.055	0.009	0.012	0.013	0.025	0.011	0.013
G-02	0.288	0.169	0.097	0.028	0.176	0.055	0.058	0.024	0.018	0.037	0.004	0.007	0.010	0.013	0.010	0.004
G-03	0.220	0.120	0.096	0.049	0.160	0.040	0.112	0.053	0.018	0.050	0.007	0.018	0.014	0.017	0.012	0.013
G-04	0.210	0.203	0.136	0.028	0.122	0.079	0.059	0.033	0.010	0.049	0.011	0.011	0.011	0.020	0.007	0.010
G-05	0.242	0.152	0.090	0.035	0.179	0.056	0.083	0.035	0.018	0.044	0.007	0.012	0.013	0.018	0.009	0.008
G-06	0.226	0.110	0.093	0.031	0.142	0.000	0.104	0.023	0.051	0.119	0.000	0.014	0.030	0.026	0.022	0.011
G-07	0.297	0.084	0.088	0.008	0.157	0.018	0.099	0.014	0.061	0.086	0.018	0.012	0.023	0.014	0.012	0.006
G-08	0.285	0.081	0.079	0.006	0.182	0.014	0.113	0.014	0.054	0.090	0.010	0.005	0.030	0.017	0.016	0.005
G-09	0.293	0.138	0.094	0.031	0.167	0.034	0.069	0.022	0.028	0.064	0.007	0.013	0.015	0.019	0.003	0.005
G-10	0.410	0.185	0.128	0.041	0.061	0.008	0.010	0.000	0.042	0.083	0.011	0.016	0.003	0.003	0.000	0.000
G-11	0.213	0.105	0.088	0.012	0.168	0.028	0.133	0.020	0.042	0.085	0.013	0.008	0.028	0.029	0.017	0.011
G-12	0.258	0.178	0.102	0.023	0.172	0.064	0.078	0.006	0.020	0.051	0.006	0.006	0.011	0.020	0.004	0.001
G-13	0.182	0.083	0.089	0.016	0.176	0.027	0.150	0.049	0.030	0.083	0.014	0.010	0.030	0.026	0.021	0.015
G-14	0.272	0.077	0.063	0.017	0.178	0.018	0.208	0.022	0.045	0.065	0.015	0.020	0.000	0.000	0.000	0.000
G-15	0.269	0.090	0.067	0.022	0.227	0.043	0.098	0.029	0.040	0.060	0.000	0.010	0.020	0.023	0.000	0.000
G-16	0.281	0.096	0.070	0.000	0.202	0.024	0.127	0.000	0.050	0.072	0.000	0.000	0.039	0.023	0.016	0.000
G-17	0.261	0.118	0.077	0.000	0.168	0.036	0.122	0.020	0.041	0.071	0.013	0.000	0.024	0.023	0.014	0.013
G-18	0.156	0.176	0.118	0.036	0.134	0.082	0.090	0.045	0.017	0.064	0.008	0.014	0.013	0.029	0.007	0.012
G-19	0.271	0.117	0.078	0.027	0.161	0.024	0.132	0.033	0.035	0.059	0.005	0.008	0.014	0.013	0.011	0.012
G-20	0.214	0.124	0.104	0.029	0.140	0.053	0.163	0.030	0.025	0.049	0.009	0.012	0.014	0.016	0.006	0.011
G-21	0.000	0.619	0.000	0.155	0.000	0.116	0.000	0.110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G-22	0.000	0.373	0.000	0.123	0.000	0.317	0.000	0.187	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G-23	0.188	0.211	0.066	0.087	0.096	0.122	0.114	0.116	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

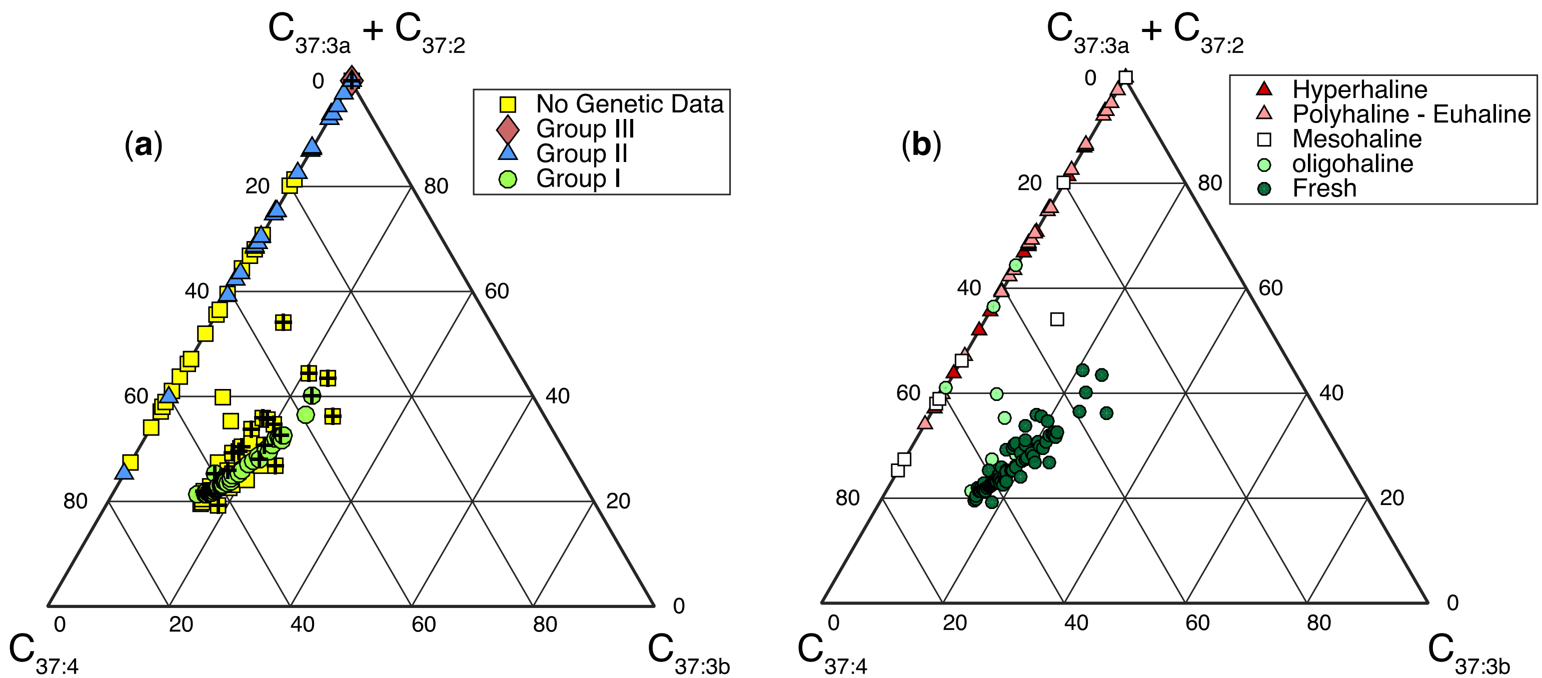

Fig. S1. Ternary diagrams demonstrating the relative proportions of various C_{37} LCAs in several environmental samples. Samples classified by Haptophyte phylogeny (a) cluster into distinct regions on the ternary diagram. New samples analyzed for this study are indicated with a "+" and all other samples include algal culture experiments and environmental samples that were analyzed with methods that separate the tri-unsaturated isomers (Longo et al., 2013; Theroux et al., 2013; Zhao et al., 2014; Longo et al., 2016). Using the same dataset, samples also cluster into distinct regions based on lake salinity (b) with the fresh lakes and Group I phylotype both plotting in the center of the diagram, indicating significant abundance of the $C_{37:3b}$ tri-unsaturated isomer.

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