Supplementary Information

Supplementary Text S1. Monte Carlo simulations and derivation of probability density functions.

In order to avoid random event sampling during the Monte Carlo (MC) simulations, the ranges for the end-member values were restricted to -1000 to 150 ‰ for $\Delta^{14}C$ and -40 to 0 ‰ for $\delta^{13}C$. Additional runs were performed with narrower ranges, resulting in small changes in the standard deviations, but only very minimal changes in the calculated mean values. This suggests that the current range (-1000 to 150 ‰ for $\Delta^{14}C$ and -40 to 0 ‰ for $\delta^{13}C$) does not impose any bias on the calculated distribution functions (probability density functions). This observation reflects the small numerical spread of the distributions compared to the allowed range.

We tested the repeatability and predictability for the MC calculations. When repeating a given calculation at least 5 times the variation in the calculated mean is typically less than 0.3%. This value is much less than the standard deviations calculated from the probability density functions (Table S1). This shows that the current calculations have a high precision and that the calculated standard deviations are due to the numerical spread of the end-member values.

In order to test the predictability of the method, calculations were run where the input data ($\delta^{13}C_{sample}$ and $\Delta^{14}C_{sample}$ in Eq. (2) and (3)) were set to the mean end-member values for the different sources: riverine, erosion and marine (Table S1). These calculations show that the marine source has the best repeatability (94%) followed by erosion (83%) and riverine (76%). These values are influenced by both the mean and the standard deviation of the end-member values. The reason that 100% repeatability is not obtained is simply because the standard deviations of the end-member distributions are not equal to zero. The high repeatability for marine samples is mainly due the small standard deviations for the end-members. Even though the standard deviation for $\Delta^{14}C$ in erosion is much larger (201‰ on total range of 1150‰, gives 17%) than for riverine sources (68‰ on total range of 1150‰, gives 6%) the repeatability for erosion is higher. This can be explained by the separation of the mean value for erosion from the marine and riverine values.

It is interesting to note that the standard deviations of the repeatability calculations (0.03 – 0.11) are generally lower compared to the values obtained for the field samples (0.07 – 0.15). This suggests that there is some numerical ambiguity in the field samples, which can be explained simply by the fact that they are derived from mixed sources and as such are partially numerically overlapping.

Calculating statistical parameters from the probability density functions

The mean (μ) and standard deviation (σ) were calculated from the probability density functions (p(i), where $\sum_{i=1}^{N} p(i) = 1$) according to:

$$\mu = \sum_{i=1}^{N} ip(i)$$

$$\sigma = \sqrt{\sum_{i=1}^{N} (i - \mu)^2 p(i)}$$

where N is the bin size in the histograms (N = 256).

Supplementary Table S1 Statistical parameters for repeatability calculated from the distribution functions using the mean end-member source values as input data (given as mean±standard deviation).

source	$\Delta^{14}C$	$\delta^{13}C$ (‰)	riverine	erosion	marine
riverine	-296	-29.3	0.76±0.11	0.12±0.09	0.11±0.07
erosion	-788	-25.8	0.11±0.07	0.83±0.06	0.07±0.05
marine	25	-21.0	0.04±0.03	0.02±0.02	0.94±0.03

Supplementary Table S2. Concentrations (μg/gOC) of *n*-alkanes and homohopanes in surface sediments and surface water suspended particulate matter (n.d. is not detected).

n-alkanes	Surface sediments								Surface particulate matter				
	34B	35	36	37	38	39	40	41	34B	35	37	39	41
14	0.86	0.032	7.4	4.6	3.8	0.75	0.99	0.33	n.d.	n.d.	n.d.	n.d.	n.d.
15	0.82	0.16	5.5	2.2	2.8	1.8	1.1	1.0	n.d.	n.d.	n.d.	n.d.	0.85
16	2.1	0.90	30	16	14	10	6.8	5.0	n.d.	5.6	n.d.	2.1	6.3
17	2.6	2.0	34	5.8	7.5	19	7.6	7.3	41	10	4.4	2.0	8.5
18	4.2	3.7	41	21	8.9	20	11	4.9	24	23	6.0	n.d.	n.d.
19	11	4.7	25	11	7.4	20	8.4	6.5	16	23	3.7	6.0	9.3
20	11	7.5	39	23	11	24	12	18	31	44	4.9	6.1	21
21	42	20	97	50	60	73	25	56	52	28	4.3	17	20
22	30	23	100	47	34	48	23	48	41	30	9.0	8.5	21
23	120	61	250	130	90	84	58	92	97	39	15	10	41
24	38	36	170	74	42	36	30	30	44	33	19	7.8	29
25	170	86	390	200	140	97	91	77	120	53	31	13	65
26	28	23	100	57	31	28	30	20	46	38	43	13	46
27	300	120	500	250	170	110	120	90	66	35	18	17	48
28	24	16	68	34	22	18	22	14	n.d.	8.1	7.3	14	15
29	210	110	470	210	170	100	110	81	23	14	15	20	42
30	8.0	7.1	36	22	13	9.7	14	8.2	n.d.	10	30	n.d.	n.d.
31	190	130	580	250	170	110	130	91	n.d.	17	12	23	53
32	4.5	4.3	17	11	7.1	4.8	6.2	3.7	n.d.	n.d.	n.d.	n.d.	n.d.
33	62	47	170	120	53	37	44	35	n.d.	n.d.	n.d.	n.d.	n.d.
ββ-C_{29} hopane	4.0	4.0	19	15	14	14	20	13	n.d.	n.d.	n.d.	n.d.	n.d.
ββ -C_{30} hopane	11	5.5	14	13	12	9.3	30	19	n.d.	n.d.	n.d.	n.d.	n.d.
ββ -C_{31} hopane	4.0	4.3	22	14	13	13	20	11	n.d.	n.d.	n.d.	n.d.	n.d.

Supplementary Table S3. Concentrations (μg/gOC) of *n*-alkanoic acids in surface sediments and surface water suspended particulate matter (n.d. is not detected).

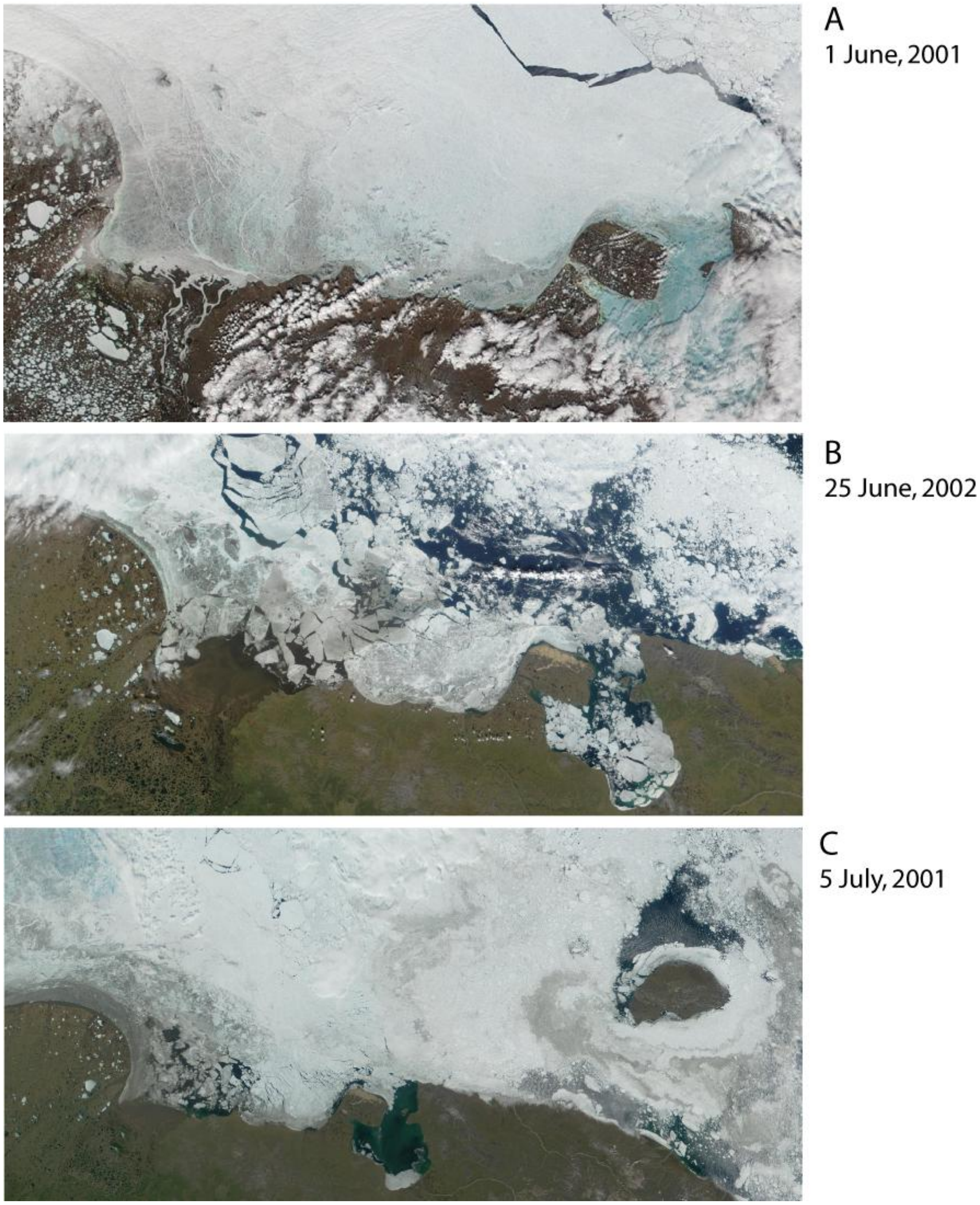
n-alkanoic acids	Surface sediments								Surface particulate matter				
	34B	35	36	37	38	39	40	41	34B	35	37	39	41
12	6.5	12	48	74	190	300	31	70	120	100	95	86	140
13	2.3	3.9	5.3	23	40	63	8.8	16	96	41	71	29	34
14	66	320	170	1600	930	2200	450	670	600	5300	4100	2400	5700
15	21	31	88	340	820	1000	150	230	190	170	270	230	250
16	310	530	1000	5600	n.d.	11000	n.d.	n.d.	7600	13000	7600	5400	13000
17	16	13	15	56	79	78	29	37	39	60	54	81	82
18	170	120	120	540	630	830	220	180	860	1900	1300	680	2800
19	17	13	8.8	26	26	19	12	12	8.9	21	5.1	5.1	13
20	180	88	49	130	120	140	38	39	81	74	61	28	110
21	110	65	37	75	46	26	19	20	22	14	6.3	3.0	14
22	690	430	210	550	280	160	130	120	140	65	67	27	190
23	370	300	140	310	170	71	94	75	41	24	8.1	3.8	43
24	960	860	510	1400	660	320	460	370	140	84	33	28	180
25	180	240	130	320	160	70	130	110	30	23	3.8	4.9	32
26	520	650	400	1100	550	210	460	390	63	44	9.6	11	91
27	70	130	73	170	100	43	90	88	9.4	8.7	2.6	2.9	19
28	400	610	300	820	400	150	350	370	33	28	7.4	8.2	79
29	43	86	50	120	66	36	58	63	n.d.	n.d.	n.d.	n.d.	12
30	180	300	150	360	190	87	160	190	15	n.d.	5.3	6.8	39
31	26	45	30	47	31	22	30	32	n.d.	n.d.	n.d.	n.d.	n.d.
32	59	110	40	110	75	48	72	82	n.d.	n.d.	n.d.	n.d.	n.d.

Supplementary Table S4. Concentrations (μg/gOC) of *n*-alkanols, sterols and stanols in surface sediments and surface water suspended particulate matter (n.d. is not detected).

n-alkanols	Surface sediment								Surface particulate matter				
	34B	35	36	37	38	39	40	41	34B	35	37	39	41
14	0.43	0.96	2.4	6.9	16	21	2.7	7.6	46	30	520	170	190
15	0.087	0.23	0.45	1.1	6.4	71	0.40	0.27	0.15	n.d.	1.4	2.5	0.89
16	1.3	2.2	4.6	13	24	39	5.4	9.7	78	38	570	139	200
17	0.33	0.38	0.54	0.81	0.62	2.0	0.60	0.75	0.32	n.d.	1.2	0.55	1.0
18	2.0	1.8	2.2	4.4	2.8	3.7	2.3	2.8	3.0	4.3	14	5.4	15
19	1.8	1.6	1.9	2.3	0.95	1.7	0.77	0.99	n.d.	n.d.	0.91	0.27	0.90
20	32	24	20	30	13	9.7	9.3	10	1.5	3.1	4.4	1.9	6.5
21	13	14	13	17	8.1	6.3	5.4	5.8	0.60	1.3	1.5	0.63	2.4
22	94	33	60	75	47	43	35	48	3.2	5.5	7.5	6.2	14
23	12	16	17	18	9.8	7.9	7.9	10	0.51	n.d.	0.98	0.66	2.4
24	46	39	47	47	26	20	23	35	1.1	1.0	2.8	1.4	8.1
25	5.4	8.3	12	12	5.8	4.4	16	6.7	0.24	n.d.	0.76	0.28	1.7
26	74	28	100	77	55	35	39	59	2.0	n.d.	4.7	2.6	20
27	3.5	5.1	8.2	7.7	4.1	3.0	6.0	5.3	n.d.	n.d.	n.d.	n.d.	0.88
28	46	53	91	71	45	34	47	74	2.5	n.d.	11	5.7	16
29	1.4	1.9	3.5	3.1	1.4	1.3	1.5	2.3	n.d.	n.d.	n.d.	n.d.	n.d.
30	6.7	8.7	14	12	6.0	4.3	5.8	8.4	n.d.	n.d.	n.d.	n.d.	n.d.
31	0.55	0.84	1.7	0.85	0.59	0.50	0.82	0.99	n.d.	n.d.	n.d.	n.d.	n.d.
32	1.5	2.3	4.1	3.2	1.8	1.8	3.4	3.1	n.d.	n.d.	n.d.	n.d.	n.d.
sterols and stanols													
asterosterol[a]	0.68	1.9	2.6	4.5	5.7	8.4	6.6	2.3	0.76	820	320	110	230
cis-22-dehydrocholesterol[b]	0.28	0.35	1.2	0.73	1.5	1.4	n.d.	1.3	n.d.	50	140	76	120
trans-22-dehydrocholesterol[c]	1.6	3.1	2.2	5.6	6.3	10	4.1	4.7	1.5	3200	160	86	79
cholesterol[d]	21	23	11	19	24	21	31	17	3.0	1900	410	290	170
brassicasterol[e]	4.8	8.2	5.1	15	38	53	20	13	2.9	4600	240	55	110
24-methylenecholesterol[f]	1.9	3.7	4.3	10	17	17	4.6	11	1.5	560	190	200	58
campesterol[g]	5.8	5.7	12	17	48	25	21	39	0.30	130	18	n.d.	n.d.

stigmasterol[h]	5.8	6.3	3.3	5.6	6.6	5.6	5.0	7.2	0.56	150	18	9.2	8.5
β-sitosterol[i]	73	31	10	23	39	35	13	22	1.3	n.d.	190	n.d.	75
isofucosterol[j]	n.d.	n.d.	n.d.	n.d.	8.4	7.5	1.2	6.3	1.2	410	100	n.d.	67
dinosterol[k]	0.28	0.77	0.53	0.95	2.0	1.4	1.9	2.7	n.d.	n.d.	11	7.1	6.5
cholestanol[l]	1.5	2.8	1.9	3.9	9.9	3.2	4.7	19	0.11	41	17	15	9.8
campestanol[m]	1.3	1.2	1.5	5.0	17	22	9.5	14	n.d.	n.d.	n.d.	n.d.	n.d.
stigmastanol[n]	9.6	5.8	2.6	6.4	6.9	8.3	4.3	6.5	n.d.	n.d.	n.d.	n.d.	n.d.

IUPAC names sterols and stanols: [a]24-nor-5α-cholesta-7,trans-22-dien-3β-ol, [b]cis-(22E)-cholesta-5,22-dien-3β-ol, [c]trans-(22E)-cholesta-5,22-dien-3β-ol, [d]cholest-5-en-3β-ol, [e](22E)-ergosta-5,22-dien-3β-ol, [f]ergosta-5,24(24')-dien-3β-ol, [g]campest-5-en-3β-ol, [h](22E)-stigmasta-5,22-dien-3β-ol, [i]stigmast-5-en-3β-ol, [j](24Z)-stigmasta-5,24(24')-dien-3β-ol, [k]4,23,24-trimethyl-5α-cholest-22-en-3β-ol, [l]5α-cholestane-3β-ol, [m]24-Methyl-5α-cholestan-3β-ol, [n]24-Ethyl-5α-cholestan-3β-ol



Supplementary Figure S1. Satellite images (from www.visibleearth.nasa.gov) illustrating the ice conditions in the Kolyma coastal region in early summer. (A) Land-fast ice is still present at the mouth of the delta. The brown color of the ice likely reflects suspended and bottom sediments from coastally eroded material (visible as turbidity clouds on Fig. 1B) that are incorporated in the sea ice during autumn freeze-up. This sediment-laden sea ice can be transported over long distances; (B) and (C) show the development of the Kolyma River plume during freshet, with part of the fluvial material flooding on top of the ice cover in the East Siberian Sea.