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Contents

Supplementary Figures S1-S5

Figure S1 consists of a schematic showing the main findings of the paper; Figure S2 shows the sampling locations; Figure S3 shows radiochronological sediment core data; Figure S4 and S5 show isotopic values for our defined end-members.

Supplementary Methods

This contains detailed information on the sampling campaigns, bulk elemental and isotope analyses, and sediment flux calculations, followed by a thorough description of the end-members used for dual-carbon isotopic mixing model (including individual description of topsoil-PF, ICD-PF and marine end-members), and the Monte Carlo simulations. The Muostakh Island methods consist of a study area description, sampling description, elemental and isotopic carbon analysis, lipid extraction, fractionation and analysis, and analysis of CO_2 fluxes.

Supplementary Tables S1-S10

Table S1 and S2 show a summary of bulk geochemical data and sediment flux data, respectively; Tables S3 and S4 contain the data that were used for the end-member values; Table S5 summarizes the relative contribution of the three defined sources; Table S6 summarizes the coastal and shelf carbon fluxes; Table S7 and S8 contains data from Muostakh Island; Tables S9 and S10 contain raw bulk geochemical and radiochronological data, respectively.

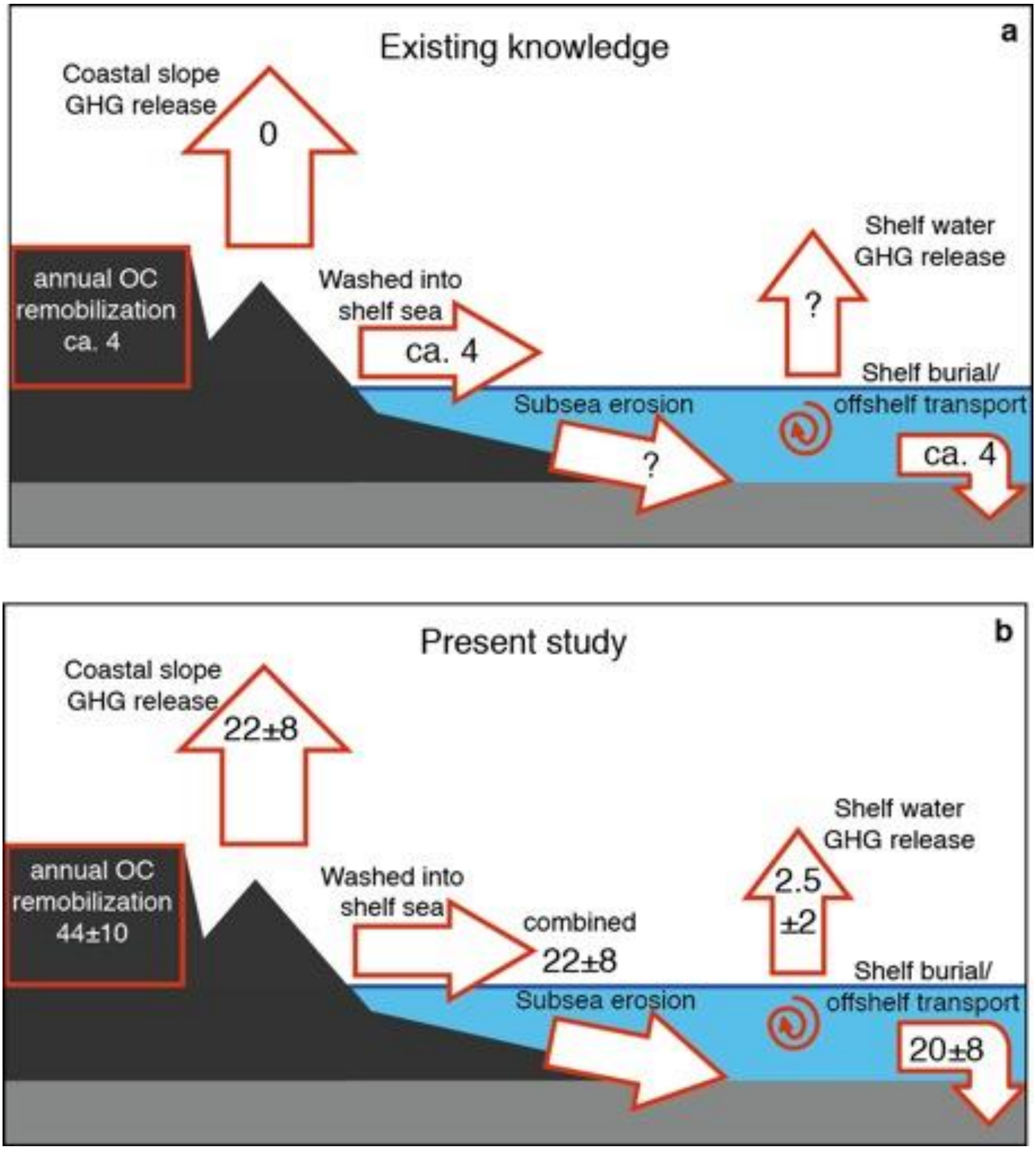

Figure S1 | Coastal erosion fluxes from Ice Complex and subsea permafrost in the ESAS.
a, The existing knowledge[1-6] on remobilization of coastal OC excludes sub-aerial degradation and acknowledges an unknown fate of this carbon in the coastal ocean. **b**, The current study on remobilization of coastal OC includes release of greenhouse gases (GHG) on the coastal slopes and details shelf degradation and deposition fluxes. All numbers reported as Tg OC/yr (mean±95% confidence interval).

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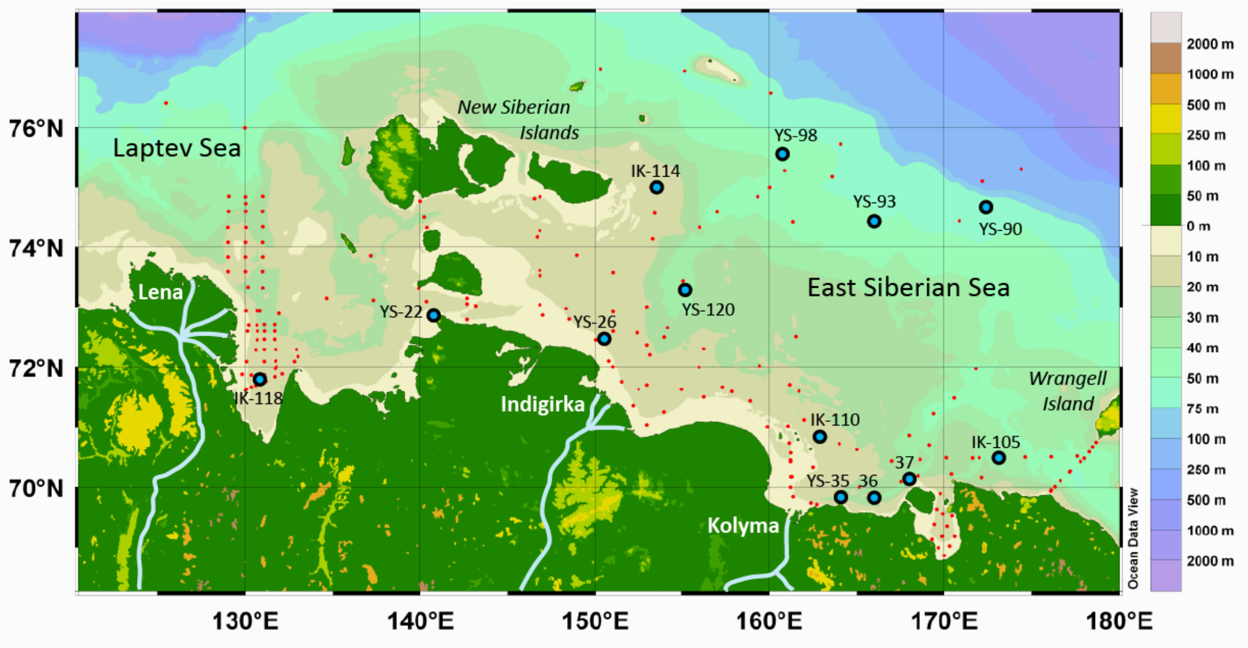

Figure S2 | Sampling locations in the East Siberian Arctic Shelf region

Map of the Laptev and East Siberian Seas showing all sampling locations for surface sediments (in red) and sediment cores (in blue).

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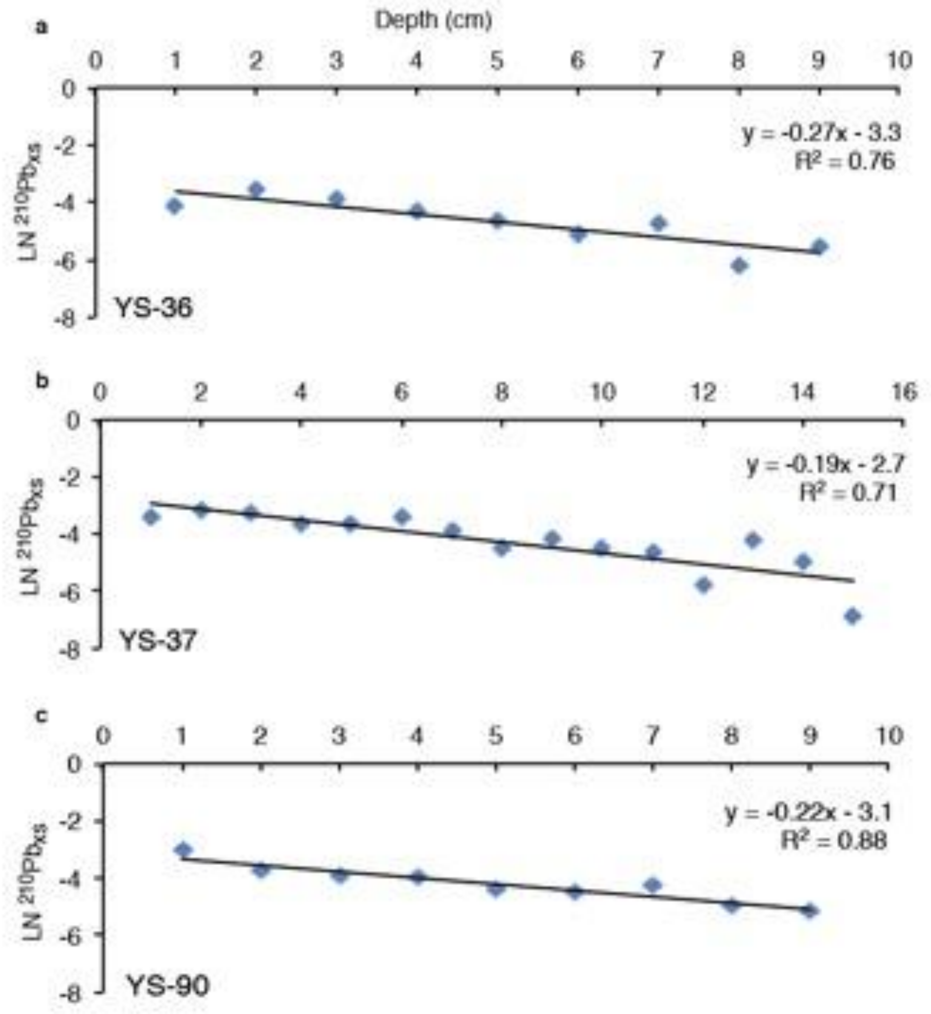

Figure S3 | Radiochronological data for East Siberian Sea sediment cores.

Regression plots of the natural logarithm of excess ^{210}Pb (LN $^{210}Pb_{xs}$) against core depth (cm) for sediment cores **a**, YS-36, **b**, YS-37 and **c**, YS-90.

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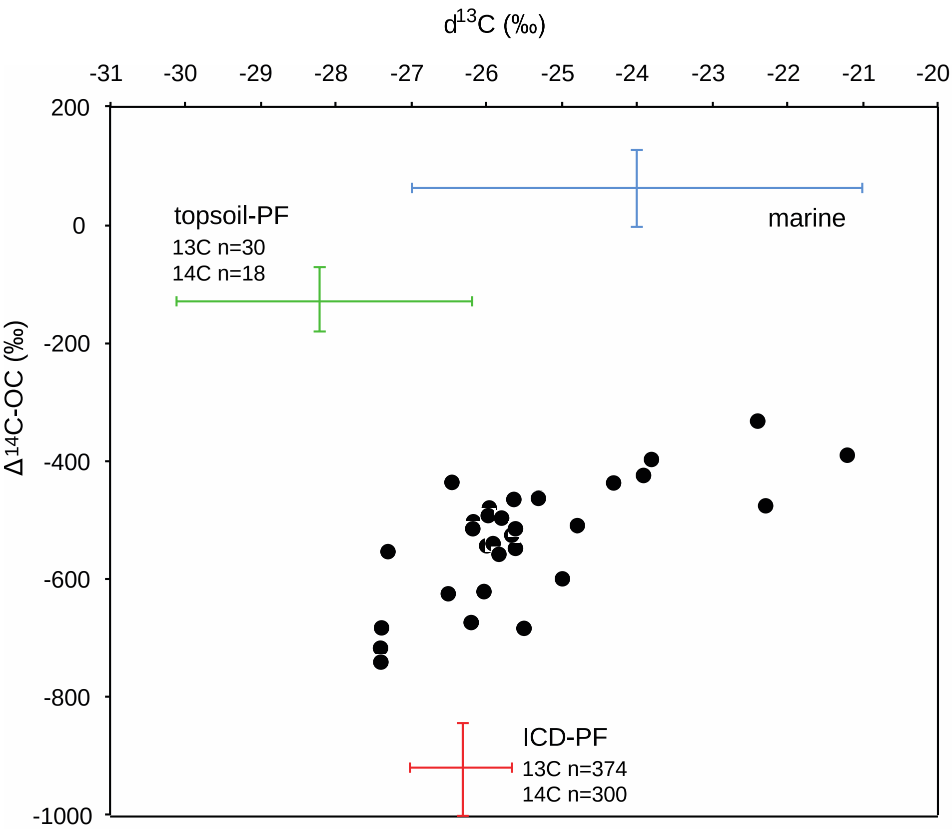

Figure S4 | Isotopic values for topsoil-PF, ICD-PF and marine end-members

Isotopic ranges that are used to define the marine, topsoil-PF, and ICD-PF end-members. Central values and references for applied range: marine $\delta^{13}C$ -24±3.0‰, $\Delta^{14}C$ +60±60‰ (refs 1, 7-17; Fig. S5; these papers report ranges, not individual data points), topsoil-PF $\delta^{13}C$ -28.2±1.96‰ $\Delta^{14}C$ -126±54‰ (Table S3; refs 18-19, http://arcticgreatrivers.org/data, unpublished data from ISSS-08 and The Polaris Project), ICD-PF $\delta^{13}C$ -26.3±0.67‰ $\Delta^{14}C$ -940±84‰ (Table S4; refs 20-40). Further explanation can be found in the Supplementary text. Black points refer to surface sediment values in the East Siberian Sea and Laptev Sea.

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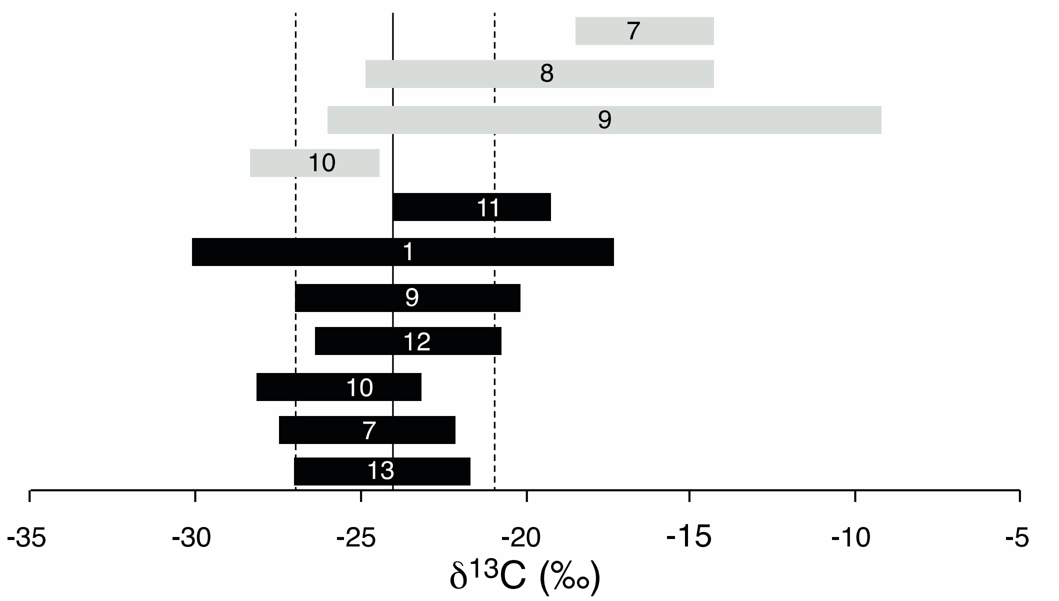

Figure S5 | Literature values on $\delta^{13}C$ signature of marine particulate organic matter and ice algae

Reported literature values for $\delta^{13}C$ on ice algae (grey bars, refs 7-10) and marine particulate organic matter (black bars, refs 1, 7, 9-13). Numbers on bars indicate references.

Supplementary Methods

Sampling campaigns

Surface sediments were collected at 83 stations during August/September 2008 as part of the International Siberian Shelf Study 2008 (ISSS-08) onboard the H/V *Yakob Smirnitskiy* and the smaller ship H/V *TB-0012* (Fig. S2). They were collected with a Van Veen grab sampler and a dual gravity corer (GEMAX, Kart Oy, Finland; modified at Stockholm University). The surface layers of the grab samples were retrieved with stainless steel spatulas, transferred into polyethylene containers and frozen until analysis. The sediment cores were sectioned into 1 cm slices with an extruder (Kart Oy, Finland), and likewise transferred into polyethylene containers and frozen until analysis.

Further sampling was performed in the Laptev and East Siberian Seas on several separate expeditions using the mid-size hydrographic vessels *Ivan Kireev* (2003/2004) and *Viktor Buynitskiy* (2007) (Fig. S2). For 117 stations, surface sediments were collected with a Van Veen grab sampler. The surface layers of the grab samples were retrieved with stainless steel spatulas, transferred into polyethylene containers and frozen until analysis.

Bulk elemental and isotope analyses

From the ISSS-08 (n=83) and 2007 (n=20) stations, around 10 mg dried (60°C, 24 h), ground and homogenized sediment was weighed into pre-combusted silver capsules (5 x 9 mm, Säntis Analytical AG, Teufen, Switzerland). The samples were acidified *in situ* with 50 µl 1M HCl to remove carbonates and dried overnight at 60°C[42]. Total organic carbon (TOC) and total nitrogen (TN) content, as well as its $\delta^{13}C$ signal were measured on triplicate samples using an elemental analyzer (EA) isotope ratio mass spectrometer (Europe Hydra 20/20, University of California, Davis Stable Isotope Facility, USA).

Elementary (TOC) and isotopic ($\delta^{13}C$) composition of bottom sediments (n=97) for the 2003, 2004 and 2007 expeditions were determined by Carlo Erba elemental analyzers and a Finnigan MAT Delta Plus isotope ratio mass spectrometer, respectively, at the International Arctic Research Center, University of Alaska, Fairbanks (USA). Accuracy and reproducibility of the isotope results were within $\delta^{13}C$ ±0.1‰.

A subset of 30 samples was freeze-dried (Christ Alpha 2-4, LSC with low carbon vacuum hybrid pump, Vacubrand RC-6; Martin Christ, Labex Instrument AB, Sweden) and sent to the U.S. National Ocean Sciences Accelerator Mass Spectrometry (NOSAMS) facility of the Woods Hole Oceanographic Institution (WHOI, Woods Hole, USA). Here the samples were acidified to remove carbonates and analyzed for bulk organic ^{14}C content by AMS.

Sediment flux calculations

The $^{210}Pb_{xs}$ activity of the sediment cores IK-105, IK-110, IK-114, IK-118, YS-22, YS-26, and YS-93 was derived based on measurements by Stockholm University with a co-axial low-energy gamma spectrometer (EG&G ORTEC) with a High-Purity Germanium (HPGe) detector. The ^{210}Pb and ^{226}Ra were analyzed in gas-tight containers about three weeks after sealing. Self-absorption corrections and thus overall counting efficiencies of the 46 keV line from ^{210}Pb were done using an external ^{210}Pb point source[43], which for Stockholm University was a calibrated U-Th series pitchblende standard (Stackebo, Sweden). The measurements were blank subtracted and decay corrected to date of collection. Cores YS-35, YS-36, YS-37, YS-90, YS-98 and YS-120 were measured at the Radiation Research Division of the Risø National Laboratory for Sustainable Energy (Roskilde, Denmark) using low-energy HPGe detectors with a carbon entrance window. Most cores from these shallow shelves were unable to show a clear age-depth chronology, presumably caused by sediment resuspension, bioturbation and ice scouring effects, yet a few cores may be used for dating (Fig. S3). However, even in the absence of a linear sedimentation rate, it is possible to derive an average (over the mean lifetime of ^{210}Pb) sediment accumulation flux. Using the depth-integrated inventory of excess ^{210}Pb ($^{210}Pb_{xs}$), we were able to estimate annual OC accumulation rates (e.g., ref. 44). For each core slice (0-1cm, 1-2cm, 2-3cm, etc.), the excess ^{210}Pb can be calculated according to:

$$^{210}Pb_{xs}\ [Bq/gdw] = A\ ^{210}Pb\ [Bq/gdw] - A^{226}Ra\ [Bq/gdw] \quad (1)$$

where A is the activity. For each slice, excess ^{210}Pb in Bq/gdw can be converted into Bq/cm^2 through multiplication with (1-porosity), dry density [g/cm^3] and slice interval [cm]. Subsequently, the total $^{210}Pb_{xs}$ in [*Bq/cm^2*] per core can then be calculated from:

$$^{210}Pb_{xs}\ [Bq/cm^2] = \Sigma_{all\ slices}[^{210}Pb_{xs}[Bq/gdw] \times (1\text{-}porosity) \times dry\ density\ [g/cm^3] \times slice\ interval\ [cm]] \quad (2)$$

Porosities were calculated and salinity-corrected for the YS-cores. The values decreased downcore, and were generally higher on the outer shelf regions (71-92% in 0-1 cm, 37-51% for deepest slice; YS-90, 98, 120) than close to the coast (44-62% in 0-1 cm, 26-37% for deepest slice; YS-35, 36, 37). Dry densities measured for the YS-cores gave an average value of 2.7 g/cm^3 (n=6, stdev 0.36). The IK-cores were assumed to have porosities of 0.7 in the top slice and 0.6 deeper down, and dry densities of 2.7 g/cm^3.

The mean life of ^{210}Pb ($\tau = 1/\lambda = 32.17$ yr) can be used to derive $^{210}Pb_{xs}$ [*Bq/cm^2/yr*]:

$$^{210}Pb_{xs}\ [Bq/cm^2/yr] = {}^{210}Pb_{xs}\ [Bq/cm^2] / \tau \quad (3)$$

The total inventories of $^{210}Pb_{xs}$ are between 16±3.9 and 383±40 Bq/m^2/yr (mean±stdev; Table S2, S10), which is comparable to the suggested global range of unsupported ^{210}Pb of 50–150 Bq/m^2/yr (ref. 45), and comparable to fluxes in the northeast Atlantic (67-100 Bq/m^2/yr (ref 44 and references therein)).

Finally, the annual sediment OC accumulation can be derived as follows:

$$Flux\ OC\ [mg\ OC/m^2/yr] = {}^{210}Pb_{xs}\ [Bq/m^2/yr]\ x\ (OC_{z=0}\ [mgOC/gdw] / A^{210}Pb_{xs\ at\ z=0}\ [Bq/gdw]) \quad (4)$$

Note that for the cores YS-120, IK-114 and IK-118 there still was $^{210}Pb_{xs}$ left in the deepest core section, and their annual OC accumulation rates are therefore minimal numbers.

When sediment cores are not mixed or bioturbated, one can calculate the sedimentation rate through the slope of the regression of the natural logarithm of $^{210}Pb_{xs}$ against sediment depth.

$$S = -\lambda / m \quad (5)$$

where S is sedimentation rate (cm/yr), λ is the decay constant of ^{210}Pb (0.031) and m is the slope. We tested this approach on sediment cores YS-36, YS-37, and YS-90 where the degree of mixing seemed only minor (Fig. S3). This resulted in sedimentation rates of 0.11 to 0.16 cm/yr and OC accumulation fluxes of 28-52 gOC/m^2/yr. The latter numbers are of similar magnitude as the fluxes in Table S2 (based on equation 4).

<u>End-members for dual-carbon isotopic mixing model</u>

We have applied a dual-carbon ($\delta^{13}C$ and $\Delta^{14}C$) isotopic mixing model, similar to refs 46 and 47, to distinguish between three sources (Fig. S4): (i) topsoil permafrost (topsoil-PF) OC, the topsoil of the terrestrial permafrost (ii) Ice Complex permafrost (ICD-PF) OC, consisting of Ice Complex deposits (coastal and inland, but predominantly exposed at the coast) and subsea permafrost and (iii) marine OC (Fig. S4). We define two different terrestrial end-members to be able to derive relative contributions of (a) contemporary terrestrial material (vegetation debris, topsoils, shallow active layer) that is delivered from inland by rivers and from the top of coastal bluffs through erosion and collapse, and (b) (late) Pleistocene Ice Complex material that is delivered through coastal, delta and riverbank erosion, and deep thermokarst. The following three equations are used:

$$F_{topsoil\text{-}PF} + f_{ICD\text{-}PF} + f_{marine} = 1 \quad (6)$$

$$\delta^{13}C_{sample} = f_{topsoil\text{-}PF}\,\delta^{13}C_{topsoil\text{-}PF} + f_{ICD\text{-}PF}\,\delta^{13}C_{ICD\text{-}PF} + f_{marine}\,\delta^{13}C_{marine} \quad (7)$$

$$\Delta^{14}C_{sample} = f_{topsoil\text{-}PF}\,\Delta^{14}C_{topsoil\text{-}PF} + f_{ICD\text{-}PF}\,\Delta^{14}C_{ICD\text{-}PF} + f_{marine}\,\Delta^{14}C_{marine} \quad (8)$$

Where $f_{topsoil\text{-}PF}$, $f_{ICD\text{-}PF}$ and f_{marine} are the fractions for topsoil permafrost OC, coastal Ice Complex permafrost OC and marine OC contribution to the samples, respectively.

Topsoil-PF end-member

The topsoil-PF $\delta^{13}C$ end-member (-28.2‰; stdev 1.96‰) is derived from a seasonal survey (April-May-June) of Kolyma and Lena River POC (n=17; -28.4‰, stdev 2.1‰) and DOC data (n=13; -28.0‰, stdev 1.8‰) from literature[18,19] and unpublished data (http://arcticgreatrivers.org/data; ISSS-08; The Polaris Project; Table S3). We chose Spring/early Summer data only, to ensure water flow is restricted to shallow flow paths (i.e. topsoils) as active layer deepening is still absent or minimal. Similarly, the topsoil-PF $\Delta^{14}C$ value (-126‰; stdev 54‰) is derived from the mean of POC (n=5, Vonk et al., unpublished results; -319‰, stdev 83‰) and DOC (n=13; -66.1‰, stdev 46‰) data[18,19]. The end-member values are calculated as the average of POC and DOC data (Table S3). Monte Carlo test simulations with stronger weighing of POC or DOC (2/3 POC and 1/3 DOC, or 1/3 POC and 2/3 DOC) for a range of stations with variable topsoil-PF contributions showed only small shifts in topsoil-PF contributions (-0.11 to +2.6% or -0.21 to -1.8%, respectively).

ICD-PF end-member

The $\delta^{13}C$ value of the ICD-PF end-member (-26.3‰, stdev 0.67‰, n=374) is taken from a recently published review[20] that in detail describes the characteristics and origin of Ice Complex deposits in Siberia. We have calculated a mean value from the data in this paper (ref. 20, page 18/Table 5), using the mean values of 12 different sites and weighing them based on the number of samples. The $\Delta^{14}C$ value of the ICD-PF end-member (-940‰, stdev 84‰, n=300) is based on a large amount of data from a range of circum-arctic studies (mostly Russia, but also Alaska and NW Canada) on Ice Complex deposits[20-40] (Table S4). These papers typically report ^{14}C ages as ky B.P., and we therefore have converted these ages into Fraction modern ($Fm = e^{-age/8033}$) and subsequently into $\Delta^{14}C$ (‰; $\Delta^{14}C = [Fm \times [e^{lambda(1950-Yc)} - 1] \times 1000$, where lambda is 1/(true mean-life of ^{14}C) or 1/8267, and we have assumed Yc (year of collection) to be 1990). In total, these papers include 300 ^{14}C data points.

Marine end-member

Literature reports on a wide range of marine $\delta^{13}C$ values for marine particulate organic matter in Arctic waters (Fig. S5, refs 1,7,9-13). Seasonally higher contributions of ice algae OC to the sedimentary OC are likely only minimal (4-26% of total primary production in seasonally icecovered waters, ref. 48), but could also deliver a variety of $\delta^{13}C$ signatures. We measured a value of -24.0‰ (triplicate measurement, analytical error 0.016%) on plankton during ISSS-08, which we have decided to use as the central end-member value. Based on Arctic literature, we will apply a standard deviation of 3.0‰ (i.e. a range of -27‰ to -21‰) for the Monte Carlo simulations (Fig. S5).

We have tested different marine end-member values for two stations (YS-90; outer shelf, YS-30, nearshore) that showed maximal and minimal marine inputs (54% and 7%, respectively, for the -24±3.0‰ end-member value). Monte Carlo simulations with two considerably different marine end-member values (-27±3‰, and -21±3‰) showed only a <1% shift in the ICD-PF contributions (similar stdev). The marine contribution shifted between 2.2-3.8% (stdevs ca. 1% larger), with a lower marine contribution for the -21±3‰ marine value, and a higher marine contribution for the -27±3‰ marine value. The topsoil-PF contribution showed the opposite: it shifted by 2.1-4.1% (stdevs 1-2% larger), decreasing when the -27±3‰ marine value is used, and increasing when a marine value of -21±3‰ is adopted. These test simulations show that even with a moderate change in the stable carbon isotopic composition of the marine end-member, our calculated ICD-PF contributions are robust and do not show significant variation.

No known measurements are available on $\Delta^{14}C$ on plankton-POC in the East Siberian or Laptev Seas, but dissolved inorganic carbon (DIC) values in the central Arctic Ocean (surface waters) range between 0 and 120‰[13-16]. Since DIC is most likely the signal taken up also in primary production, we have therefore chosen to apply a central value of +60‰ with a range of 60‰ (i.e. +60±60‰, mean±stdev) in order to account for the 0 to 120‰ literature data.

Monte Carlo simulations

The quantification of the relative source contributions (topsoil-PF, ICD-PF and marine) to the surface sediment OC content was estimated using a recently developed Monte Carlo (MC) method[49] (also used by refs 46 and 47). Briefly, mean values and standard deviations are calculated from the $\delta^{13}C$ and $\Delta^{14}C$ data for the three different sources. These values are used to generate the parameters of log-normal distributions that reproduce these values on the 0 – 1 interval. These log-normal distributions thus are approximations of the source profiles for the different carbon isotope ratios. A comparison between representing the source distributions by log-normal or normal distributions showed small differences (~1%) in the calculated sources values[49]. Random sampling is then performed from these log-normal distributions, while simultaneously satisfying a mass-balance and 0 - 1 constraints, generating a large number of solutions. The experimental data points are represented by normal distributions, using the measurement errors as the standard deviations. Solutions from the random sampling are sorted into histograms, generating probability density functions (PDFs). From the PDFs, the mean and standard deviations are calculated. The MC calculations were run using in-house written Matlab scripts, utilizing Matlab version 7.9.0 (The MathWorks, Natick, USA). We collected 100,000 random sampling events satisfying the boundary conditions for each sample, and the results were sorted into histograms with bin size of 256.

Muostakh Island case study

Muostakh Island study area

Muostakh is a very small island (ca. 2 km by 13 km) situated in a continuous permafrost region[50] in the southeastern Laptev Sea (71.60 ºN; 130.02 ºE), within the Buor-Khaya Bay (Figures 1 and 3). Coastal erosion in the Laptev Sea has been described to be the major supplier of sediments, with ratios over riverine input amounting to 2.5[2]. High cliffs and seasonal ice melting in the Laptev and East Siberian Sea result in higher erosion rates than for other Arctic coasts[51]. Consisting mainly of Cenozoic (geological era corresponding to the last 65,000 years) deposits, Muostakh Island rises up to ~25 m above sea level of Ice Complex containing discrete masses of detrital soil between ice wedges. The matrix of these bodies is mostly composed of silt and organic-rich silt (69±11% silt and 28±11% clays), with minor contribution of sand (2.5±0.4%) and a rather homogeneous granulometric distribution along the island[52].

Average shoreline retreat rate in Muostakh is estimated to vary from ~1 to 20 m/yr, on the basis of a few present-day field measurements of shorelines and comparison with remote sensing information, and study of satellite images and aerial photographs from the period 1951-2002[2-6]. The loss of ICD-OC due to downslope degradation was estimated from the decrease of the soil OC content at the higher sites relative to those at the lower sampling sites in each slope (Table S7). Slope 2 lost 80% of its OC downslope ((3.5%-0.69%)/3.5%) (Table S7), whereas slopes 5 and 6 lost 49% and 68% OC, respectively. This resulted in 66±16% (mean±stdev) of original OC in the IC being lost to, presumably mostly, CO_2 during downslope transport of the thawed/thawing material.

Muostakh Island sampling description

In July 2006, soil samples (0.3-40 g) were collected from different profile height along four different slopes of the Ice Complex bluff of the northern part of Muostakh Island (Fig. 3; Table

S7). The samples were dried and kept frozen until elemental (TOC and TN), isotopic (^{13}C and ^{14}C) and molecular biomarkers analysis.

Muostakh Island elemental and isotopic carbon analysis

Subsamples of dried and finely ground soil were weighed (5-50 mg) into pre-combusted silver capsules (5 x 9 mm, Säntis Analytical AG, Teufen, Switzerland). The soil TOC content and stable isotopic carbon signatures ($\delta^{13}C$) were measured at Stockholm University (Department of Geological Sciences, Sweden), by means of a Carlo Erba NC2500 elemental analyzer connected via a split interface to a Finnigan MAT Delta Plus isotope ratio mass spectrometer. Prior to analysis, the bulk soil was acidified with 1 M HCl to remove carbonates, and dried (60º C, 24 h). Similarly, larger soil subsamples (4-70 mg) were decarbonated with 1M HCl, dried and sent to NOSAMS for ^{14}C analyses.

Muostakh Island lipid extraction, fractionation and analysis

For the molecular biomarker analysis, freeze-dried soil samples between 0.1 and 5 g (depending on the soil OC content) were extracted with dichloromethane/methanol (DCM/MeOH, 2:1 (v/v)), using Soxhlet or Accelerated Solvent Extraction. Internal standards (D_{50}-tetracosane, D_{39}-eicosanoic acid and 2-hexadecanol) were added prior to extraction. The total lipid extracts were concentrated, cleaned, separated into non-polar, polar and acid fractions with Bond-Elut® (bonded phase NH_2, Varian, Middelburg, The Netherlands) and Al_2O_3 column chromatography and derivatized as described in ref. 53. Laboratory blanks revealed slight contamination of the C_{16} and C_{18} *n*-alkanoic acids, most likely derived from the Bond-Elut® columns[54]. No significant contamination was detected for any or the target analytes. Recoveries were found to be 73±38% on average. Identification and quantification of the non-polar, polar and acid fractions was performed by gas chromatography/mass spectrometry (GC/MS). We used a GC8060 equipped with an on-column injector and interfaced to a MD800 MS (both Fisons PLC, Ipswich, Suffolk, UK), operating with electron ionization at 70 eV and scanning from m/z 50 to 600. The analytes were injected (1 µl) on-column and separated on a PTE-5 (Supelco Inc, Bellefonte, USA) capillary column (5%-diphenyl-dimethylpolysiloxane, length 30 m, I.D. 0.25mm, film thickness 0.25 µm). The transfer line to the mass spectrometer was kept at 300 °C, with the ion source at 240 °C. Temperature program settings and compounds identification is described in detail by ref. 53.

Analysis of the CO_2 fluxes on Muostakh Island

The emission of CO_2 from the thawing ICD permafrost was measured simultaneously to the soil moisture content in early (7-12) September 2006. The measurements were taken along five aboveground transects crossing the northern part of Muostakh Island from west to east (Fig. 3B). The CO_2 sampling transects roughly followed the soil sampling slopes, in order to assess potential emissions derived from the ICD degradation suggested by the bulk and molecular analyses. *In situ* CO_2 analysis was carried out with automatic lid chambers attached to an infrared gas analyzer (LICOR 8100), according to procedures detailed elsewhere[55]. At the heart of the LICOR 8100 System lies the Analyzer Control Unit (ACU), an O-ring sealed, weather-tight enclosure that houses system electronics and the infrared gas analyzer (IRGA) used to measure the change in CO_2 and H_2O concentrations in the soil chamber. The different mechanisms controlling the opening and closing of the long-term chambers do not affect the measurements. Both chambers lower slowly onto the measurement site to minimize pressure pulsations that change soil CO_2 concentrations. In total, CO_2 emissions were measured in duplicate or triplicate (3 minutes per measurement) from 30 sampling sites along the five transects. Although most of the CO_2 sampling was realized on land (n=28), two CO_2 measurements were collected at shallow-submerged sites of one transect, to check the CO_2 out-gassing beyond the shoreline. Respiration fluxes are reported as mmol/m^2/day (Fig. 3B) and represent average values of the duplicate or triplicate measurements.

The CO_2 fluxes measured in Muostakh Island (3.2 to 440 mmol/m^2/day; Table S8) were in the range of respiration fluxes (192-442 mmol/m^2/day) measured in July 1998 on unvegetated Ice Complex in the Kolyma River basin, NE Siberia[56], but around one order of magnitude higher than in situ measurements on Ice Complex scarps of the neighboring Primorsky coastal plain (high Arctic tundra near Tiksi) (8.6-95 mmol/m^2/day), and modeled future (yrs. 2050-2100) CO_2 fluxes from Ice Complex in the Yakutsk area of 46 mmol/m^2/day[57]. When vegetation is absent, larger CO_2 fluxes are measured on the IC slopes of Muostakh Island, suggesting significant ongoing degradation.

References

1. Stein, R. & Macdonald, R. W. Eds. *The Organic Carbon Cycle in the Arctic Ocean.* (Springer, Berlin, 2004).
2. Rachold, V. *et al.* Coastal erosion vs riverine sediment discharge in the Arctic Shelf seas. *Int. J. Earth Sci.* **89**, 450-460 (2000).
3. Are, F. E. *Thermal Abrasion of Sea Coasts* (Nauta Publ. Moscow, 1980).
4. Overduin, P. P. *et al.* The evolution and degradation of coastal and offshore permafrost in the Laptev and East Siberian Seas during the last climatic cycle. *Geol. S. Am. S.* **426**, 97-110 (2007).

5. Semiletov, I. P. Destruction of the coastal permafrost ground as an important factor in biogeochemistry of the Arctic Shelf waters. *Dokl. Earth Sci.* **368**, 679-682 (1999).
6. Grigoriev, M. N. & Kunitsky, V. V. *Ice complex of the Arctic coast of Yakutia as a source of detrital deposits on the shelf, Hydrometeorological and biogeochemical researches in Arctic regions*, The Arctic Areal Centre, issue II, part. 1 (Vladivostok: Dalnauka, 2000).
7. Schubert, C. J. & Calvert, S. E. Nitrogen and carbon isotopic composition of marine and terrestrial organic matter in Arctic Ocean sediments: implications for nutrient utilization and organic matter composition. *Deep-Sea Res. I* **48**, 789-810 (2001).
8. Gradinger, R. Sea-ice algae: Major contributors to primary production and algal biomass in the Chukchi and Beaufort Seas during May/June 2002. *Deep-Sea Res. II* **56**, 1201-1212 (2009).
9. Tremblay, J.-E., Michel, C., Hobson, K. A., Gosselin, M. & Price, N. M. Bloom dynamics in early opening waters of the Arctic Ocean. *Limnol. Oceanogr.* **51**(2), 900-912 (2006).
10. Iken, K., Bluhm, B. A. & Gradinger, R. Food web structure in the High Arctic Canada basin: Evidence from d13C and d15N analysis. *Polar Biol.* **28**, 238-249 (2005).
11. Goñi, M. A., Yunker, M. B., Macdonald, R. W. & Eglinton, T. I. Distribution and sources of organic biomarkers in arctic sediments from the Mackenzie River and Beaufort Shelf. *Mar. Chem.* **71**, 23-51 (2000).
12. O'Brien, M. C., Macdonald, R. W., Melling, H. & Iseki, K. Particle fluxes and geochemistry on the Canadian Beaufort Shelf: Implications for sediment transport and deposition. *Cont. Shelf Res.* **26**, 41-81 (2006).
13. Goericke, R. & Fry, B. Variations of marine plankton d13C with latitude, temperature, and dissolved CO_2 in the world ocean. *Global Biogeochem. Cycles* **8**, 85-90 (1994).
14. Griffith, D. R. *et al.* Carbon dynamics in the Western Arctic Ocean: insights from full-depth carbon isotope profiles of DIC, DOC and POC. *Biogeosciences* **9**, 1217-1224 (2012).
15. Schlosser, P. *et al.* On the 14C and 39Ar distribution in the central Arctic Ocean: Implications for deep water formation. *Radiocarbon* **36**(3), 327-343 (1994).
16. Schlosser, P. *et al.* The first trans-Arctic 14C section: comparison of the mean ages of the deep waters in the Eurasian and Canadian basins of the Arctic Ocean. *Nucl. Instrum. Methods B* **123**, 431-437 (1997).
17. Key, R. M. *et al.* A global ocean carbon climatology: Results from Global Data Analysis Project (GLODAP). *Global Biogeochem. Cycles* **18**, GB4031 (2004).
18. Neff, J. *et al.* Seasonal changes in the age and structure of dissolved organic carbon in Siberian rivers and streams. *Geophys. Res. Lett.* **33**, L23401 (2006).

19. McClelland, J. W. *et al.* Development of a pan-arctic database for river chemistry. *EOS Trans. AGU* **89**, 217-218 (2008).
20. Schirrmeister, L. *et al.* Sedimentary characteristics and origin of the Late Pleistocene Ice Complex on north-east Siberian Arctic coastal lowlands and islands – A review. *Quatern. Int.* **241**, 3-25 (2011).
21. Müller, S., Bobrov, A. A., Schirrmeister, L., Andreev, A. A. & Tarasov, P. E. Testate amoebae record from the Laptev Sea coast and its implication for the reconstruction of Late Pleistocene and Holocene environments in the Arctic Siberia. *Palaeogeog. Palaeocl.* **271**, 301-315 (2009).
22. Schirrmeister, L. *et al.* Late Quaternary history of the accumulation plain north of the Chekanovsky ridge (Lena delta, Russia): A multidisciplinary approach. *Polar Geography* **27**(4), 277-319 (2003).
23. Wetterich, S. *et al.* Palaeoenvironmental dynamics inferred from late Quaternary permafrost deposits on Kurungnakh Island, Lena Delta, Northeast Siberia, Russia. *Quaternary Sci. Rev.* **27**, 1523-1540 (2008).
24. Schirrmeister, L., Siegert, C., Kunitsky, V. V., Grootes, P. M. & Erlenkeuser, H. Late Quaternary ice-rich permafrost sequences as a paleoenvironmental archive for the Laptev Sea Region in northern Siberia. *Int. J. Earth Sci.* **91**, 154-167 (2002).
25. Andreev, A. A. *et al.* Paleoenvironmental changes in Northeastern Siberia during the Late Quaternary – Evidence from pollen records of the Bykovsky Pensinsula. *Polarforschung* **70**, 13-25 (2002).
26. Grosse, G. *et al.* Geological and geomorphological evolution of a sedimentary periglacial landscape in Northeast Siberia during the Late Quaternary. *Geomorphology* **86**, 25-51 (2007).
27. Slagoda, E. A. *Genesis and microstructure of cryolithogenic deposits at the Bykovsky Peninsula and the Muostakh Island*. PhD Thesis. Russian Academy of Science, Siberian Branch, Permafrost Institute Yakutsk (in Russian).
28. Kanevski, M., Shur, Y., Fortier, D., Jorgenson, M. T. & Stephani, E. Cryostratigraphy of the late Pleistocene syngenetic permafrost (yedoma) in northern Alaska, Itkillik River exposure. *Quaternary Res.* **75**, 584-596 (2011).
29. Carter, L. D. Loess and deep thermokarst basins in Arctic Alaska. *Proceedings of the Fifth International Conference on Permafrost*. Tapir Publishers, Trondheim, Norway, pp. 706-711 (1988).
30. Dutta, K., Schuur, E. A. G., Neff, J. C. & Zimov, S. A. Potential carbon release from permafrost soils of Northeastern Siberia. *Glob. Change Biol.* **12**, 2336-2351 (2006).

31. Vasil'chuk, Y. K., van der Plicht, J., Jungner, H., Sonninen, E. & Vasil'chuk, A. C. First direct dating of Late Pleistocene ice-wedges by AMS. *Earth Planet. Sc. Lett.* **179**, 237-242 (2000).
32. Vasil'chuk, Y. K. & Vasil'chuk, A. C. Radiocarbon dating and oxygen isotope variations in Late Pleistocene syngenetic ice-wedges, Northern Siberia. *Permafrost Perigl.* **8**, 335-345 (1997).
33. Vasil'chuk, Y. K. Heterochroneity and heterogeneity of the Duvanny Yar Edoma. *Dokl. Earth Sci.* **402**(4), 568-573 (2005).
34. Vasil'chuk, Y. K. & Vasil'chuk, A. C. Oxygen-isotope and C14 data associated with Late Pleistocene syngenetic ice-wedges in mountains of Magadan region, Siberia. *Permafrost Periglac.* **9**, 177-183 (1998).
35. Westgate, J. A., Preece, S. J., Kotler, E. C. & Hall, S. Dawson tephra: a prominent stratigraphic marker of late Wisconsinan age in west-central Yukon, Canada. *Can. J. Earth Sc.* **37**, 621-627 (2000).
36. Froese, D., Westgate, J., Preece, S. & Storer, J. Age and significance of the Late Pleistocene Dawson tephra in eastern Beringia. *Quaternary Sci. Rev.* **21**, 2137-2142 (2002).
37. Fraser, T. A. & Burn, C. R. On the nature and origin of "muck" deposits in the Klondike area, Yukon Territory. *Can. J. Earth Sc.* **34**, 1333-1344 (1997).
38. Kotler, E. & Burn, C. R. Cryostratigraphy of the Klondike "muck " deposits, west-central Yukon Territory. *Can. J. Earth Sc.* **37**, 849-861 (2000).
39. Péwé, T. L., Journaux, A. & Stuckenrath, R. Radiocarbon dates and Late-Quaternary stratigraphy from Mamontova Gora, unglaciated central Yakutia, Siberia, U.S.S.R. *Quaternary Res.* **8**, 51-63 (1977).
40. Zech, M. *et al.* Characterisation and palaeoclimate of a loess-like permafrost palaeosol sequence in NE Siberia. *Geoderma* **143**, 281-295 (2008).
41. Sánchez-García, L. *et al.* Inventories and behavior of particulate organic carbon in the Laptev and East Siberian seas. *Global Biogeochem. Cycles* **25**, GB2007 (2011).
42. Gustafsson, Ö., Haghseta, F., Chan, C., MacFarlane, J. & Schwend, P. M. Quantification of the dilute sedimentary soot phase: Implications for PAH speciation and bioavailability. *Environ. Sci. Technol.* **31**, 203-209 (1997).
43. Cutshall, N. H. Larsen, I. L. & Olsen, C. R. Direct analysis of ^{210}Pb in sediment samples: self adsorption corrections. *Nucl. Instrum. Methods* **206**, 309-312 (1983).
44. Carvalho, F. P. Oliveira, J. M. & Soares, A. M. M. Sediment accumulation and bioturbation rates in the deep Northeast Atlantic determined by radiometric techniques. *ICES J. Mar. Sci.* **68**, 427-435 (2011).

45. Appleby, P. G. & Oldfield, F. Application of lead-210 to sedimentation studies. In: Ivanovich, M. and Harmon, R.S., Eds., *Uranium-series Disequilibrium: Application to Earth, Marine and Environmental Sciences*, Clarendon Press, Oxford, pp. 731–738 (1992).
46. Vonk, J. E. *et al.* Molecular and radiocarbon constraints on sources and degradation of terrestrial organic carbon along the Kolyma paleoriver transect, East Siberian Sea. *Biogeosciences* **7**, 3153-3166 (2010).
47. Karlsson, E. S. *et al.* Carbon isotopes and lipid biomarker investigation of sources, transport and degradation of terrestrial organic matter in the Buor-Khaya Bay, SE Laptev Sea. *Biogeosciences* **8**, 1865-1879 (2011).
48. Legendre, L. *et al.* Ecology of sea ice biota, 2. Global significance. *Polar Biol.* **12**, 429-444 (1992).
49. Andersson, A. A systematic examination of a random sampling strategy for source apportionment calculations. *Sci. Total Environ.* doi:10.1016/j.scitotenv.2011.10.31 (2011).
50. Brown, J., Ferrians Jr., O. J., Heginbottom, J. A. & Melnikov, E. S. *Circum-arctic Map of Permafrost and Ground-Ice conditions.* USGS Circum-Pacific Map Series CP-45 (scale 1:10,000 000) (US-Geological Survey, 1997).
51. Forbes, D. L. (Ed.) *State of the Arctic Coast 2010 – A Scientific Review and Outlook.* International Arctic Science Committee, Land-Ocean Interactions in the Coastal Zone, Arctic Monitoring and Assessment Programme, International Permafrost Association, Helmholtz-Zentrum, Germany, 178 pp. http://arcticcoasts.org (2010).
52. Dudarev, O. V., Semiletov, I. P., Charkin, A. N. & Botsul, A. I. Deposition settings on the continental shelf of the East Siberian Sea. *Dokl. Earth Sci.* **409**(6), 822-827 (2006).
53. Vonk, J. E., van Dongen, B. E. & Gustafsson, Ö. Lipid biomarker investigation of the origin and diagenetic state of sub-arctic terrestrial organic matter presently exported into the northern Bothnian Bay. *Mar. Chem.* **112,** 1-10 (2008).
54. Russell, J. M. & Werne, J. P. The use of solid phase extraction columns in fatty acid purification. *Org. Geochem.* **38**, 48-51 (2007).
55. Semiletov, I., Makshtas, A., Akasofu, S.-I. & Andreas, E. L. Atmospheric CO_2 balance: The role of Arctic sea ice. *Geophys. Res. Lett.* **31**, L05121 (2004).
56. Zimov, S. A. *et al.* Permafrost carbon: Stock and decomposability of a globally significant carbon pool. *Geophys. Res. Lett.* **33**, L20502 (2006).
57. Khvorostyanov, D. V. *et al.* Vulnerability of permafrost carbon to global warming. Part II: sensitivity of permafrost carbon stock to global warming. *Tellus* **60B**, 265-275 (2008).

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Table S1 | Summary of bulk geochemical data for surface sediments in the East Siberian Arctic Shelf.

Mean, maximum and minimum values for sediment organic carbon (OC), $\delta^{13}C$ contents, and TOC/TN mass ratios for 200 surface sediment stations in the Laptev and East Siberian Seas. All individual data can be found in Table S9. The $\delta^{13}C$ and ^{14}C age are measured relative to VPDB and Oxalic Acid I standards, respectively

Region	n	sed. OC[1] mg/gdw	Max Min	$\delta^{13}C$ (‰)	max min	TOC/TN[1]	max min	n	$\Delta^{14}C$ (‰)	max min
Laptev Sea										
North of 73°N	26	9.11	19.2	-25.6	-24.3	9.59	15.3	3	-486	-557
			0.300		-26.2		3.00			-437
South of 73°N	38	18.2	25.8	-25.9	-25.2	11.4	14.9	11	-516	-622
			3.17		-27.5		9.40			-436
Dmitry Laptev /Sannikov Straits	10	9.92	20.8	-27.0	-25.8	9.42	12.5	1	-716	-
			3.88		-27.4		6.93			-
East Siberian Sea										
West of 160°E	47	10.7	20.4	-25.8	-23.8	11.7	16.3	5	-675	-741
			4.06		-28.3		6.63			-600
East of 160°E	38	11.1	20.1	-25.5	-23.8	8.80	14.9	4	-514	-624
			3.90		-27.3		6.08			-425
Outer shelf (>40 m depth)	15	8.49	10.4	-23.3	-21.2	5.66	6.17	5	-422	-511
			7.60		-24.8		5.24			-332
Chaunskaya Bay	12	11.9	25.3	-25.9	-24.4	10.9	13.0	-	-	-
			1.30		-27.0		8.00			-
Long Strait	14	16.1	21.9	-23.2	-21.9	8.42	10.8	-	-	-
			11.0		-24.3		6.35			-

[1]For sediment OC and TOC/TN, outliers have been excluded (3 and 8 values respectively). Outliers are defined as observations farther than 1.5 * interquartile range from the closest quartile.

Table S2 | Fluxes of organic carbon to surface sediments in the East Siberian Arctic Shelf.

Sediment core locations can be found in Fig. S2.

Station	Core length (cm)	Depth (m)	Total core $^{210}Pb_{xs}$ (Bq/m^2/yr)	stdev	OC bottom slice[1] (mg/gdw)	Activity ^{210}Pb (Bq/gdw)	OC flux to sediment[2] (gOC/m^2/yr)
					Laptev Sea		
IK-118-A[3]	58	15	197	15	18	0.058	60
					East Siberian Sea		
					West		
YS-22[3]	15	20	313	14	12	0.029	130
YS-26[3]	14	16	178	11	8.7	0.036	43
YS-35	11	31	38.7	6.4	13	0.030	17
IK-110-A	13	17	16.2	3.9	4.7	0.010	7.6
IK-114-A[3]	40	16	26.2	3.2	6.2	0.009	18
					Central		
YS-36	14	32	51.1	6.3	11	0.016	33
YS-37	15	42	123	8.8	12	0.033	43
YS-98	12	48	87.1	11	9.4	0.022	38
YS-120[3]	11	33	249	13	11	0.076	36
IK-105-A	25	37	383	40	14	0.134	40
					East/outer		
YS-93[3]	14	51	140	10	8.0	0.038	29
YS-90	17	63	51.2	8.5	7.2	0.048	7.7
						mean±95%CI[4]	36±17

[1] For YS-22, YS-26 and YS-93, the OC content of the top slice was used. The other cores showed no clear difference between OC content in the top versus bottom; the values were comparable and without any significant decrease downcore.

[2] According to: *Flux sediment OC [mg OC/m^2/yr] = $\Sigma_{all\ slices}$ $^{210}Pb_{xs}$ [Bq/m^2/yr] x ($OC_{z=0}$ [mgOC/gdw] / A$^{210}Pb_{xs\ at\ z=0}$ [Bq/gdw]).* Further details can be found in the method section.

[3] The deepest core slice still contained $^{210}Pb_{xs}$. The sediment OC accumulation fluxes for these stations are therefore minimal estimates.

[4] 95% confidence interval for n=12 data points (East Siberian Sea only).

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Table S3 | Topsoil-PF end-member source data

Combined literature and unpublished $\delta^{13}C$ and $\Delta^{14}C$ results on POC and DOC in the Kolyma and Lena Rivers during April, May and June (multiple years), used as source data for the topsoil-PF end-member.

River	Sampling date	$\delta^{13}C$ (‰)		$\Delta^{14}C$ (‰)		Source
		POC	DOC	POC	DOC	
Kolyma River	11-Jun-04	-26.5	-27.3		86.8	Ref. 19
	15-Jun-04	-28.1	-30.0		-3.9	Ref. 19
	25-Jun-04	-29.7	-27.4		44.8	Ref. 19
	22-Apr-05	-34.6	-27.2		20.4	Ref. 19
	30-Jun-05	-30.5	-26.1		-12.7	Ref. 19
	05-Jun-09	-27.4				http://arcticgreatrivers.org/data
	12-Jun-09	-27.3				http://arcticgreatrivers.org/data
	21-Jun-09	-28.0				http://arcticgreatrivers.org/data
	11-Jun-03		-32.2		52.6	Ref. 18
	30-Jun-03		-27.9		52.7	Ref. 18
	28-May-03		-30		116	Ref. 18
	30-Apr-11			-203		Vonk et al., unpublished
	01-Jun-11			-286		Vonk et al., unpublished
	31-May-11			-310		Vonk et al., unpublished
	14-Jun-11			-387		Vonk et al., unpublished
	13-Jun-11			-410		Vonk et al., unpublished
Lena River	09-Apr-04	-31.5	-27.2		63.0	Ref. 19
	05-Jun-04	-27.7	-27.3		120	Ref. 19
	07-Jun-04	-27.4	-28.3		121	Ref. 19
	27-May-05	-27.8	-25.2		112	Ref. 19
	04-Jun-05	-26.9	-27.3		87.0	Ref. 19
	06-Jun-06	-27.8				Ref. 19
	31-May-09	-27.1				http://arcticgreatrivers.org/data
	05-Jun-09	-27.2				http://arcticgreatrivers.org/data
	11-Jun-09	-26.6				http://arcticgreatrivers.org/data
Mean		-29.0	-28.5	-319	44.6	
Average POC+DOC		-28.2		-126.4		

Table S4 | ICD-PF end-member source data

Collected $\Delta^{14}C$ data from literature on Ice Complex deposits in Siberia, Alaska and Canada, used as source data for the ICD-PF end-member.

Sample/ Lab ID #	Location	Lat (°N)	Long (°E)	Height[1] (m)	Material	^{14}C[2] (yrs BP)	$\Delta^{14}C$[2,3] (‰)	Ref.[4]	Comments[5]
Kha-2-1	Khardang Sise Island	72.95	124.2	3.1	peat inclusion	43550	-996	20	min. age
Kha-2-3	Khardang Sise Island	72.95	124.2	4.3	peat inclusion	49030	-998	20	min. age
Kha-2-7	Khardang Sise Island	72.95	124.2	5	peat moss	52090	-998	20	min. age
Kha-2-13	Khardang Sise Island	72.95	124.2	6.6	peat	50200	-998	20	min. age
Kha-2-18	Khardang Sise Island	72.95	124.2	8.6	plant fragments	29770	-976	20	
Kha-2-24	Khardang Sise Island	72.95	124.2	10.1	wood fragments	28050	-970	20	
Kha-2-32	Khardang Sise Island	72.95	124.2	16.9	plant remains	20100	-918	20	
Muo-3-1	Muostakh	71.61	129.9	0.5	plant remains	39110	-992	20	
Muo-3-5	Muostakh	71.61	129.9	1	twigs	46780	-997	20	
Muo-3-4	Muostakh	71.61	129.9	2	twigs, moss	42800	-995	20	
Muo-3-8	Muostakh	71.61	129.9	5	plant remains	38620	-992	20	
Muo-3-9	Muostakh	71.61	129.9	7.5	carex, eriophorum	40340	-993	20	
Muo-3-11	Muostakh	71.61	129.9	9.7	twigs	19560	-913	20	
STO-1-6	Stolbovoy Island	74.06	136.0	27	twigs, betula nana	50890	-998	20	min. age
STO-2-1	Stolbovoy Island	74.06	136.0	10	plant remains	40830	-994	20	min. age
STO-2-2	Stolbovoy Island	74.06	136.0	1	plant remains	36440	-989	20	min. age
STO-2-3	Stolbovoy Island	74.06	136.0	3	twigs	52250	-999	20	min. age
STO-3-1	Stolbovoy Island	74.06	136.0	5	moss	42430	-995	20	min. age
STO-3-5	Stolbovoy Island	74.06	136.0	6	moss	54940	-999	20	min. age
STO-3-8	Stolbovoy Island	74.06	136.0	6.75	twigs, moss	36580	-990	20	
BEL-2-1	Bel'kovsky Island	75.37	135.5	2.7	twigs	54390	-999	20	
BEL-3-1	Bel'kovsky Island	75.37	135.5	3.7	twigs	47660	-997	20	
BEL-3-3	Bel'kovsky Island	75.37	135.5	4.6	moss	39840	-993	20	min. age
BEL-7-1	Bel'kovsky Island	75.37	135.5	1	twigs	39980	-993	20	
Mya-1-1	N Kotel'ny Island,	76.17	139.0	1.5	lemming excrement, seeds,	27860	-969	20	
Kys-2-4	SW Kotel'ny Island,	74.73	138.4	2.7	plant remains	45960	-997	20	
KYS-2-5	SW Kotel'ny Island (K.	74.73	138.4	3	plant remains	52280	-999	20	

Kys-2-6	SW Kotel'ny Island (K.	74.73	138.4	4	moss	52790	-999	20	
Kys-2-10	SW Kotel'ny Island (K.	74.73	138.4	8.4	plant remains	35370	-988	20	
KLY-1-1	Maly Lyakhovsky	74.25	140.3	5	moss	38290	-992	20	min. age
KLY-1-4	Maly Lyakhovsky	74.25	140.3	3.3	plant remains	34680	-987	20	
KLY-1-9	Maly Lyakhovsky	74.25	140.3	1.5	twigs	27980	-969	20	
X-99-019	Cape Svyatoy Nos	72.84	140.8	14.6	plant remains	47640	-997	20	min. age
X-99-014	Cape Svyatoy Nos	72.84	140.8	9.6	plant remains	45350	-996	20	
X-99-024	Cape Svyatoy Nos	72.84	140.8	17	plant remains	50290	-998	20	min. age
X-99-025	Cape Svyatoy Nos	72.84	140.8	24	plant remains	36080	-989	20	
Oy7-08-32	Oyogos Yar coast	72.68	143.5	9.5	plant remains	41420	-994	20	
Oy7-08-37	Oyogos Yar coast	72.68	143.5	12	peat inclusion	43860	-996	20	
Oy7-08-38	Oyogos Yar coast	72.68	143.5	15.5	peat inclusion	44840	-996	20	
Oy7-08-42	Oyogos Yar coast	72.68	143.5	17.1	plant remains	48540	-998	20	
Oy7-08-47	Oyogos Yar coast	72.68	143.5	19.2	plant remains	40850	-994	20	
Oy7-08-53	Oyogos Yar coast	72.68	143.5	22	peat inclusion	44900	-996	20	
Oy7-08-57	Oyogos Yar coast	72.68	143.5	24	plant remains	38600	-992	20	
Oy7-08-62	Oyogos Yar coast	72.68	143.5	26.5	grass roots	34630	-987	20	
Oy7-08-63	Oyogos Yar coast	72.68	143.5	27	grass roots	32220	-982	20	
MaK-1-9	Cape Mamontov Klyk	73.61	117.1	4.3	fine-sand silt, grass roots	44520	-996	21	min. age
MaK-1-12	Cape Mamontov Klyk	73.61	117.1	5.3	peaty palaeosol	40410	-993	21	
MaK-2-1	Cape Mamontov Klyk	73.61	117.1	6.2	sand, organic free	37100	-990	21	min. age
MaK-2-6	Cape Mamontov Klyk	73.61	117.1	8.3	peaty palaeosol,	42260	-995	21	
MaK-2-9	Cape Mamontov Klyk	73.61	117.1	9.8	peaty palaeosol,	44310	-996	21	
MaK-3-7	Cape Mamontov Klyk	73.61	117.1	7	peaty palaeosol, fine-sand	43510	-996	21	
MaK-3-14	Cape Mamontov Klyk	73.61	117.1	10.3	peaty palaeosol, peat	43620	-996	21	
MaK-3-17	Cape Mamontov Klyk	73.61	117.1	13.2	peaty palaeosol, peat	31250	-980	21	
MaK-5-3	Cape Mamontov Klyk	73.61	117.1	14.3	palaeosol, peat inclusion,	24600	-953	21	
MaK-6-4	Cape Mamontov Klyk	73.61	117.1	16	sandy silt, vertical grass	20640	-924	21	
MaK-9-5	Cape Mamontov Klyk	73.61	117.1	21.9	fine-sand silt, wood	16510	-873	21	
MaK-10-5	Cape Mamontov Klyk	73.61	117.1	24.3	cryoturbated palaeosol,	9480	-694	21	
MaK-10-8	Cape Mamontov Klyk	73.61	117.1	25.2	cryoturbated palaeosol,	9510	-695	21	
MaK-11-2	Cape Mamontov Klyk	73.61	117.1	2.5	sandy silt, plant remains	11060	-749	21	
MaK-12-1	Cape Mamontov Klyk	73.61	117.1	0.5	peaty palaeosol, peat	27220	-966	21	

MaK-13-7	Cape Mamontov Klyk	73.61	117.1	4.3	fine-sand silt, few organic,	24150	-951	21	
MaK-15-5	Cape Mamontov Klyk	73.61	117.1	6.6	fine-sand to silt, wood	21890	-935	21	
MaK-16-5	Cape Mamontov Klyk	73.61	117.1	9.3	fine-sand to silt, wood	20180	-919	21	
MaK-17-3	Cape Mamontov Klyk	73.61	117.1	11.5	peaty palaeosol, wood	18920	-906	21	
MaK-17-7	Cape Mamontov Klyk	73.61	117.1	13.6	palaeosol	17700	-890	21	
MaK-19-3	Cape Mamontov Klyk	73.61	117.1	15.3	sand, wood and plant	16350	-870	21	
MaK-19-7	Cape Mamontov Klyk	73.61	117.1	17.1	sandy silt	14545	-837	21	
LD98 D6238	Nagym, Island Ebe-	72.88	123.3	14	Wood	47480	-997	22	min. age
L 98 D6237	Nagym, Island Ebe-	72.88	123.3	11	plant remains	42930	-995	22	
LD98 D6397	Nagym, Island Ebe-	72.88	123.3	5.1	root horizon	56790	-999	22	min. age
Nag 6+20-S-5	Nagym, Island Ebe-	72.88	123.3	22	Peat	45640	-997	22	min. age; conv. 14C
LD98 D7.502	Buor-Khaya, Island	72.33	126.3	14	root horizon	42910	-995	22	
BKh 3-S-25	Buor-Khaya (K. S.)	72.33	126.3	31	small twigs	16980	-880	22	
BKh 3-S-23	Buor-Khaya (K. S.)	72.33	126.3	28.5	peat	33490	-985	22	
BKh 3-S-19	Buor-Khaya (K. S.)	72.33	126.3	24	peat	38020	-991	22	
BKh 3-S-14	Buor-Khaya (K. S.)	72.33	126.3	21	peat	44470	-996	22	
BKh-O 65	Buor-Khaya (K. S.)	72.33	126.3	20	Equus sp. (radius)	34299	-986	22	conv. 14C
BKh 3-S-14	Buor-Khaya (K. S.)	72.33	126.3	15.9	peat inclusion	50090	-998	22	
DY II-2	Dzhangylakh/Khardan	72.95	124.2	18.8	plant remains	52690	-999	22	min. age; conv. 14C
DY II-2	Dzhangylakh/Khardan	72.95	124.2		autochthonous peat	26420	-963	22	conv. 14C
DY II-2	Dzhangylakh/Khardan	72.95	124.2	19.6	autochthonous peat	25180	-957	22	conv. 14C
Bkh2002 S20	Kurungnakh	72.33	126.3	29.2	wood	32920	-983	23	
Bkh2002 S16	Kurungnakh	72.33	126.3	29	wood	31960	-981	23	
Bkh2002 S22D	Kurungnakh	72.33	126.3	26.3	wood, leaves	34830	-987	23	
Bkh2002 S48	Kurungnakh	72.33	126.3	24	wood	40410	-993	23	
Bkh2002 S25D	Kurungnakh	72.33	126.3	23	wood, moss, coarse leaves	40020	-993	23	
Bkh2002 S46aD	Kurungnakh	72.33	126.3	19.8	moss, leaf fragments	41220	-994	23	
BKh2002 S45aD	Kurungnakh	72.33	126.3	17.9	plants	41330	-994	23	
MKh99-5	Bykovsky, Mamontovy	71.81	128.4	35.5	plant	13920	-824	24	
Mkh99-8	Bykovsky (M. K.)	71.81	128.4	33.5	plant	17160	-882	24	
Mkh99-9	Bykovsky (M. K.)	71.81	128.4	32.6	grass roots, wood	17350	-885	24	
Mkh99-23	Bykovsky (M. K.)	71.81	128.4	31	plant	19340	-910	24	
Mkh99-10	Bykovsky (M. K.)	71.81	128.4	30.2	plant	20600	-923	24	

Mkh99 R1-30m	Bykovsky (M. K.)	71.81	128.4	30	insect remains	17160	-882	24	
Mkh 00-S-1	Bykovsky (M. K.)	71.81	128.4	30	plant remains	18490	-900	24	
Mkh99-12	Bykovsky (M. K.)	71.81	128.4	28.8	grass roots, wood	22060	-936	24	
Mkh B18-28.5m	Bykovsky (M. K.)	71.81	128.4	28.5	insect remains	23750	-948	24	
Mkh99-14	Bykovsky (M. K.)	71.81	128.4	27.5	grass roots	23800	-949	24	
Mkh99-16	Bykovsky (M. K.)	71.81	128.4	26.2	grass roots, wood	24470	-953	24	
Mkh99-18	Bykovsky (M. K.)	71.81	128.4	24.7	grass roots, wood	25570	-959	24	
Mkh-4.12-2a	Bykovsky (M. K.)	71.81	128.4	24.1	peat	24460	-953	24	
Mkh99-90	Bykovsky (M. K.)	71.81	128.4	23.3	grass roots	28110	-970	24	
Mkh-KB7-5a	Bykovsky (M. K.)	71.81	128.4	22.3	wood	33580	-985	24	
Mkh-KB9-3	Bykovsky (M. K.)	71.81	128.4	22.2	wood	28470	-971	24	
Mkh-KB7-3a	Bykovsky (M. K.)	71.81	128.4	20.7	wood	33450	-985	24	
Mkh-4-14C-8	Bykovsky (M. K.)	71.81	128.4	20	peat	28502	-971	24	conv. 14C
Mkh-KB8-3	Bykovsky (M. K.)	71.81	128.4	18.5	wood	35050	-987	24	
Mkh-KB6-3	Bykovsky (M. K.)	71.81	128.4	18.4	peat, moss, grass	36020	-989	24	
Mkh-KB8-4	Bykovsky (M. K.)	71.81	128.4	17.5	wood, plant	34800	-987	24	
Mkh-KB4-6	Bykovsky (M. K.)	71.81	128.4	17.2	wood	36800	-990	24	
Mkh-KB5-2	Bykovsky (M. K.)	71.81	128.4	17.2	peat, plant	37010	-990	24	
Mkh-KB5-2	Bykovsky (M. K.)	71.81	128.4	17.2	wood	37760	-991	24	
Mkh-BR2	Bykovsky (M. K.)	71.81	128.4	16.8	shrub, wood	34740	-987	24	
Mkh-KB4-4	Bykovsky (M. K.)	71.81	128.4	16	grass roots	35860	-989	24	
Mkh-HB2-4	Bykovsky (M. K.)	71.81	128.4	15.2	peat	44980	-996	24	min. age, conv. 14C
Mkh-HB2-8	Bykovsky (M. K.)	71.81	128.4	15.6	peat	41390	-994	24	conv. 14C
Mkh-HB2-10	Bykovsky (M. K.)	71.81	128.4	15.8	peat	41830	-995	24	min. age, conv. 14C
Mkh-HB2-2	Bykovsky (M. K.)	71.81	128.4	15	peat	41740	-994	24	
Mkh-KB3-1	Bykovsky (M. K.)	71.81	128.4	15	peat, wood	39320	-993	24	
Mkh-KB2-2	Bykovsky (M. K.)	71.81	128.4	14.8	moss	44280	-996	24	
Mkh-KB1-4	Bykovsky (M. K.)	71.81	128.4	13.8	wood	44580	-996	24	
Mkh-KB1-2	Bykovsky (M. K.)	71.81	128.4	13	wood	48140	-998	24	
Mkh-K1-14C-2	Bykovsky (M. K.)	71.81	128.4	11	wood	47900	-997	24	
Mkh-3	Bykovsky (M. K.)	71.81	128.4	10	peat inclusion	45090	-996	24	
Mkh-K1-5	Bykovsky (M. K.)	71.81	128.4	10.5	moss	45300	-996	24	
Mkh-K1-14C-1	Bykovsky (M. K.)	71.81	128.4	8.8	grass	42630	-995	24	

Mkh-1.1-2	Bykovsky (M. K.)	71.81	128.4	3.4	grass roots	52870	-999	24	
Mkh-1.2-14C-1	Bykovsky (M. K.)	71.81	128.4	2.7	peat, wood	58400	-999	24	
Mkh-6.1-2	Bykovsky (M. K.)	71.81	128.4	1.3	wood	52900	-999	24	min. age
Mkh-00-10-S-1	Bykovsky (M. K.)	71.81	128.4	0.2	plant remains	54930	-999	24	
Mkh-00-10-S-1	Bykovsky (M. K.)	71.81	128.4	1.7	plant remains	57180	-999	24	
Mkh-KB9-6	Bykovsky (M. K.)	71.81	128.4	23.8	plant	10470	-730	24	
Mkh-KB-9-6	Bykovsky (M. K.)	71.81	128.4	23.9	wood	13230	-808	24	
MB-6.3-1	Bykovksy (M. K.)	71.81	128.4	1.5	plant remains	47400	-997	25	
Mkh-KB2-2	Bykovsky (M. K.)	71.81	128.4	14.8	moss remains	44280	-996	25	
Mkh-HB2-4	Bykovsky (M. K.)	71.81	128.4	15.25	peat	43080	-995	25	min. age
Mkh-HB2-8	Bykovsky (M. K.)	71.81	128.4	15.55	peat	39500	-993	25	min. age
Mkh-HB2-8	Bykovsky (M. K.)	71.81	128.4	15.55	peat	36350	-989	25	
Mkh-HB2-10	Bykovsky (M. K.)	71.81	128.4	15.75	peat	38610	-992	25	min. age
CM-1.2-1	Bykovsky (Cape	71.81	128.4	24	plant remains	35050	-987	25	
Mkh99-4-KIA	Bykovsky	71.81	128.4	36.4	plant remains	12790	-798	25	
Khg-11/1-KIA	Bykovsky (Khorogor	71.81	128.4	36	peat	11545	-764	26	
Khg-11/2-KIA	Bykovsky (Khorogor	71.81	128.4	35.4	peat	11710	-768	26	
Khg-11/3-KIA-	Bykovsky (Khorogor	71.81	128.4	35	peat	12145	-781	26	
Neb-1/10-KIA-	Bykovsky (Khorogor	71.81	128.4	4.2	twigs	10440	-729	26	
Neb-1/6- KIA	Bykovsky (Khorogor	71.81	128.4	3.45	peat	10690	-737	26	
Neb-1/2- KIA	Bykovsky (Khorogor	71.81	128.4	2.6	peat	11260	-755	26	
Neb-1/1-KIA	Bykovsky (Khorogor	71.81	128.4	2.1	plant remains	11400	-759	26	
Khg-17/12-KIA	Bykovsky (Khorogor	71.81	128.4	7	peat	10120	-718	26	
Khg-17/7-KIA	Bykovsky (Khorogor	71.81	128.4	6	twigs	10210	-721	26	
Khg-17/1-KIA	Bykovsky (Khorogor	71.81	128.4	4.8	peat	10190	-720	26	
Mkh02-1/1- KIA	Bykovksy peninsula	71.81	128.4	36.35	twigs	10620	-735	26	
Mkh02-1/3- KIA	Bykovksy peninsula	71.81	128.4	35.25	twigs	12890	-800	26	
Mkh02-1/5- KIA	Bykovksy peninsula	71.81	128.4	34.75	twigs	14760	-842	26	
B-S-5-KIA 8166	Bykovksy peninsula	71.81	128.4	20	wood	19330	-910	26	
B-S-7-KIA 8165	Bykovksy peninsula	71.81	128.4	10	peat	53020	-999	26	
30/82-IM-767	Bykovksy peninsula	71.81	128.4	20	peat	28180	-970	27	conv. 14C
19/82-IM-766	Bykovksy peninsula	71.81	128.4	11	peat	23700	-948	27	conv. 14C
103/81-LU-1328	Bykovksy peninsula	71.81	128.4	7	peat	21630	-933	27	conv. 14C

103/81-LU-1130	Bykovksy peninsula	71.81	128.4	6	peat	33040	-984	27	conv. 14C
103/81-GIN-4597	Bykovksy peninsula	71.81	128.4	5	plant material	40200	-993	27	conv. 14C
103/81-GIN-4593	Bykovksy peninsula	71.81	128.4	4	plant material	40400	-993	27	conv. 14C
103/81-GIN-4391	Bykovksy peninsula	71.81	128.4	2.5	plant material	40800	-994	27	conv. 14C
BK-21-1	Buor-Khaya Cape	71.92	132.6	6	bulk soil	48000	-997	*	min. age
BK-21-2	Buor-Khaya Cape	71.92	132.6	3	bulk soil	7960	-631	*	
BK-21-3	Buor-Khaya Cape	71.92	132.6	1	bulk soil	19450	-912	*	
BK-21-4	Buor-Khaya Cape	71.92	132.6	1	bulk soil	14300	-832	*	
Lena-64-5	Olenek channel	72.32	126.2	17	bulk soil	42500	-995	*	
Lena-64-7	Olenek channel	72.32	126.2	2	bulk soil	16500	-872	*	
Lena-64-8	Olenek channel	72.32	126.2	1	bulk soil	11450	-761	*	
Lena-64-9	Olenek channel	72.32	126.2	0.5	bulk soil	15800	-861	*	
M 2-5	Muostakh	71.61	129.9	13	bulk soil	17300	-884	*	
M 2-3	Muostakh	71.61	129.9	16	bulk soil	15750	-860	*	
M 5-3	Muostakh	71.61	129.9	0.5	bulk soil	25500	-958	*	
M 5-5	Muostakh	71.61	129.9	24	bulk soil	15400	-854	*	
M 6-3	Muostakh	71.61	129.9	2	bulk soil	19950	-917	*	
M 6-6	Muostakh	71.61	129.9	23	bulk soil	9380	-690	*	
M 7-5	Muostakh	71.61	129.9	23	bulk soil	35200	-988	*	
OS-66783	Alaska; Itkillik	69.57	-	3	twigs	14300	-832	28	
OS-66784	Alaska; Itkillik	69.57	-	4	twigs	16550	-873	28	
Alpha-3292	Alaska; Itkillik	69.57	-	7.4	loess	12600	-793	29	14C by
OS-66785	Alaska; Itkillik	69.57	-	11	twigs	29300	-974	28	
OS-66786	Alaska; Itkillik	69.57	-	15	twigs	26300	-962	28	
USGS-1151	Alaska; Itkillik	69.57	-	15	fine-grained org.	28610	-972	29	
I-11,530	Alaska; Itkillik	69.57	-	15	fine-grained org.	32300	-982	29	
OS-66780	Alaska; Itkillik	69.57	-	16	twigs	23900	-949	28	
AA-2361	Alaska; Itkillik	69.57	-	17.2	herbaceous plant	21800	-934	29	
Alpha-3291	Alaska; Itkillik	69.57	-	17.4	loess	34700	-987	29	
Alpha-3290	Alaska; Itkillik	69.57	-	20	loess	34700	-987	29	
OS-66787	Alaska; Itkillik	69.57	-	23	fine-grained org.	41700	-994	28	
OS-66777	Alaska; Itkillik	69.57	-	30.9	peat	48000	-997	28	min. age
OS-66778	Alaska; Itkillik	69.57	-	31.8	fine-grained org.	47500	-997	28	min. age

-	Kolyma; Medvezhka	69.65	162.5	>10m d	bulk soil	39860	-993	30	
-	Kolyma; Zelenyi Mys	68.8	161.3	>10m d	bulk soil	26700	-964	30	
363/55-Hel-3942	Yamal: Seyaha	70	72	0.8d	peat	11620	-766	31	
363/77-Hel-4023	Yamal: Seyaha	70	72	3.2d	peat	17290	-884	31	
279/10-GIN-2473	Yamal: Seyaha	70	72	8.6d	peat	22700	-941	31	
279/13-GIN-2475	Yamal: Seyaha	70	72	10d	peat	22600	-940	31	
363/207-GIN-	Yamal: Seyaha	70	72	11d	peat	22510	-940	31	
363/111-Hel-4046	Yamal: Seyaha	70	72	12d	peat	22850	-942	31	
279/16-GIN-2474	Yamal: Seyaha	70	72	12d	peat	23500	-947	31	
363/206-Hel-4043	Yamal: Seyaha	70	72	12d	peat	24460	-953	31	
363/62-Hel-4056	Yamal: Seyaha	70	72	12.2d	peat	25300	-957	31	
363/112-Hel-3943	Yamal: Seyaha	70	72	15.2d	peat	27890	-969	31	
279/23-GIN-2476	Yamal: Seyaha	70	72	16.2d	peat	24300	-952	31	
363/212-GIN-	Yamal: Seyaha	70	72	20.5d	peat	29500	-975	31	
279/28-GIN-2477	Yamal: Seyaha	70	72	20.9d	Peat	30100	-977	31	
363/211-Hel-201	Yamal: Seyaha	70	72	20.9d	Twig	31200	-980	31	
363/208-Hel-3950	Yamal: Seyaha	70	72	20.9d	Peat	36800	-990	31	
GIN-4983	Kular settlement	70.64	134.3	100	Peat	40000	-993	32	min. age
GIN-4978	Kular settlement	70.64	134.3	100	Wood	43700	-996	32	min. age
GIN-4977	Kular settlement	70.64	134.3	100.5	Wood	41100	-994	32	
GIN-4964	Kular settlement	70.64	134.3	106	Bone	40500	-994	32	
GIN-4979	Kular settlement	70.64	134.3	106.5	Peat	35700	-988	32	
GIN-4982	Kular settlement	70.64	134.3	107	Rootlets	42400	-995	32	
GIN-4987	Kular settlement	70.64	134.3	107	Peat	33300	-984	32	
GIN-4965	Kular settlement	70.64	134.3	109	Bone	38700	-992	32	
GIN-4981	Kular settlement	70.64	134.3	109	Bone	37700	-991	32	
GIN-3597	Gudar settlement	70.89	78.5	2	allochthonous OM	12300	-785	32	
GIN-3591	Gudar settlement	70.89	78.5	3	allochthonous OM	13850	-823	32	
GIN-3592	Gudar settlement	70.89	78.5	5	allochthonous OM	14400	-834	32	
GIN-3595	Gudar settlement	70.89	78.5	2	allochthonous OM	13600	-817	32	
GIN-3609	Gudar settlement	70.89	78.5	3	allochthonous OM	14590	-838	32	
GIN-3603	Gudar settlement	70.89	78.5	5	allochthonous OM	14810	-843	32	
GIN-3611	Gudar settlement	70.89	78.5	2	allochthonous OM	12090	-779	32	

GIN-3608	Gudar settlement	70.89	78.5	3	allochthonous OM	13100	-805	32
GIN-3585	Gudar settlement	70.89	78.5	5	allochthonous OM	15890	-862	32
GIN-3862	Duvanny Yar	68.62	159.1	20	Rootlets	42600	-995	32
GIN-3864	Duvanny Yar	68.62	159.1	21	Rootlets	38000	-991	32
GIN-3865	Duvanny Yar	68.62	159.1	22	Soil	35100	-987	32
GIN-4015	Duvanny Yar	68.62	159.1	25	DAOPM	37900	-991	32
GIN-4018	Duvanny Yar	68.62	159.1	30	DAOPM	33400	-984	32
GIN-3861	Duvanny Yar	68.62	159.1	38	bone	33800	-985	32
GIN-4016	Duvanny Yar	68.62	159.1	38	DAOPM	27600	-968	32
GIN-4017	Duvanny Yar	68.62	159.1	40	DAOPM	22000	-936	32
GIN-3868	Duvanny Yar	68.62	159.1	45	bone	19480	-912	32
EP-941555	Duvanny Yar	68.62	159.1	46	soil	13080	-805	32
MAG-592	Duvanny Yar	68.62	159.1	42	rootlets, stalks, branches	17850	-892	33
GIN-3867	Duvanny Yar	68.62	159.1	15	bone	28600	-972	33
GIN-4588	Duvanny Yar	68.62	159.1	10	black peat	29900	-976	33
GIN-3998	Duvanny Yar	68.62	159.1	9	rootlets, stalks, branches	30100	-977	33
GIN-3996	Duvanny Yar	68.62	159.1	7.5	rootlets, stalks, branches	35400	-988	33
GIN-8922	Utinoe	62.5	-	334.8	wood	32100	-982	34
GIN-8925	Utinoe	62.5	-	334.9	wood	31390	-980	34
GIN-8929	Utinoe	62.5	-	334	peat	42120	-995	34
GIN-8930	Utinoe	62.5	-	332.8	peat	35500	-988	34
TO-6968	Klondike, Canada	63.92	-	-	small twigs and grass	23520	-947	35
Beta-161238	Klondike, Canada	63.92	-	-	grass	23990	-950	36
Beta-161239	Klondike, Canada	63.92	-	-	draba sp. Seed	24280	-952	36
TO-8304	Klondike, Canada	63.92	-	-	peat	21880	-935	36
TO-6967	Klondike, Canada	63.92	-	-	small twigs and grass	22300	-938	35
BGS-1775	Klondike, Canada	63.92	-	-	grass bed	24025	-950	37
Beta-133410	Klondike, Canada	63.92	-	-	peat	25240	-957	36
BGS-1770	Klondike, Canada	63.92	-	-	salix sp. piece	31000	-979	37
BGS-1768	Klondike, Canada	63.92	-	-	grasses	28450	-971	37
BGS-1754	Klondike, Canada	63.92	-	-	grasses	27150	-966	37
BGS-1758	Klondike, Canada	63.92	-	-	salix sp. Piece	26240	-962	37
BGS-1755	Klondike, Canada	63.92	-	-	grasses	24025	-950	37

BGS-2015	Klondike, Canada	63.92	-	-	wood	49000	-998	38	beta-decay age
BGS-2019	Klondike, Canada	63.92	-	-	rhizomes	45500	-997	38	beta-decay age
BGS-2018	Klondike, Canada	63.92	-	-	wood	40060	-993	38	beta-decay age
TO-6968	Klondike, Canada	63.92	-	-	twigs	23520	-947	38	
TO-6967	Klondike, Canada	63.92	-	-	twigs	22300	-938	38	
Beta-111606	Klondike, Canada	63.92	-	-	twigs/grass squirrel nest	13910	-824	38	beta-decay age
TO-6869	Klondike, Canada	63.92	-	-	twigs from base	11620	-766	38	
-	Mamontova Gora	62.48	135.6	5.5	silt?	26800	-965	39	
-	Mamontova Gora	62.48	135.6	3	silt?	40600	-994	39	
-	Mamontova Gora	62.48	135.6	8	silt?	44000	-996	39	
-	Mamontova Gora	62.48	135.6	4d		34020	-986	39	
-	Mamontova Gora	62.48	135.6	5d	tree fragment	42150	-995	39	
-	Mamontova Gora	62.48	135.6	8d	unidentified mammal ribs	46700	-997	39	
-	Mamontova Gora	62.48	135.6	9d		56000	-999	39	min. age
-	Mamontova Gora	62.48	135.6	10d		56000	-999	39	min. age
-	Mamontova Gora	62.48	135.6	12d		56000	-999	39	min. age
SI-1967	Mamontova Gora	62.48	135.6	14d	wood	46000	-997	39	min. age
-	Mamontova Gora	62.48	135.6	17d		56000	-999	39	min. age
SI-1966	Mamontova Gora	62.48	135.6	23d	wood	43500	-996	39	min. age
-	Mamontova Gora	62.48	135.6	26d		56000	-999	39	min. age
W-435	Alaska, Eva Creek	64.83	-	2.5d	wood	23300	-945	39	
L-157A	Alaska, Eva Creek	64.83	-	Base	wood	23000	-943	39	min. age
L-163J	Alaska, Eva Creek	64.83	-	Base	wood	30000	-976	39	min. age
I-2116	Alaska, Eva Creek	64.83	-	Base	wood	24400	-952	39	
Hv-1328	Alaska, Eva Creek	64.83	-	-	wood?	56900	-999	39	min. age
L-137X	Alaska, Eva Creek	64.83	-	-	roots	28000	-970	39	min. age
KIA 19138	Tumura River	63.6	129.9	1.2d	humic acids	13052	-804	40	
KIA 19138	Tumura River	63.6	129.9	1.2d	humins	20285	-920	40	
KIA 19139	Tumura River	63.6	129.9	1.8d	roots	9022	-676	40	
Erl. 6152	Tumura River	63.6	129.9	2.6d	humic acids	11801	-771	40	
Erl. 6154	Tumura River	63.6	129.9	2.6d	humins	17713	-890	40	
Erl. 6157	Tumura River	63.6	129.9	2.6d	humins	19301	-910	40	
Erl. 6153	Tumura River	63.6	129.9	2.6d	Roots	9272	-686	40	

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KIA 19140	Tumura River	63.6	129.9	3d	humins	29756	-975	40	
Erl. 6155	Tumura River	63.6	129.9	3d	roots	9275	-686	40	
Erl. 6155	Tumura River	63.6	129.9	3d	roots	9240	-685	40	
Erl. 6156	Tumura River	63.6	129.9	3d	roots	8945	-673	40	
Erl. 5203	Tumura River	63.6	129.9	4.4d	wood	46000	-997	40	min. age
KIA 18805	Tumura River	63.6	129.9	5d	bone collagen	47110	-997	40	
KIA 18805	Tumura River	63.6	129.9	5d	bone collagen	49690	-998	40	
Erl. 5203	Tumura River	63.6	129.9	8.2d	wood	48000	-997	40	min. age
Erl. 5204	Tumura River	63.6	129.9	10.9d	wood	51000	-998	40	min. age

[1] with "d" indicating depth instead of height.

[2] error and/or standard deviations can be found in the cited references.

[3] the references mostly report ^{14}C ages (in yrs BP), we have converted these ages to Fraction modern (Fm = $e^{-age/8033}$) and subsequently into $\Delta^{14}C$ (‰; $\Delta^{14}C$ = [Fm x [$e^{lambda(1950-Yc)}$ – 1] x 1000, where lambda is 1/(true mean-life of ^{14}C) or 1/8267, and Yc year of collection (assumed 1990).

[4] with * indicating Sánchez-García *et al.*, unpublished results.

[5] with "conv. 14C" meaning conventional ^{14}C dating (not AMS), "min. age" meaning minimal age.

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Table S5 | Fractions of topsoil-PF, ICD-PF and marine OC in surface sediment OC in the East Siberian Arctic Shelf.

Calculated with a Monte Carlo simulation strengthened dual-carbon isotopic mixing model.

		Fraction of sediment OC (mean)			(stdev)		
Depth (m)	**Station**	**Topsoil-PF**	**ICD-PF**	**Marine**	**Topsoil-PF**	**ICD-PF**	**Marine**
			Laptev Sea				
11	YS-4	16%	46%	38%	11%	4.7%	10%
16	YS-6	25%	48%	27%	14%	5.4%	12%
14	TB-19	19%	64%	17%	10%	4.8%	8.4%
16	TB-24	20%	57%	23%	12%	5.1%	10%
5	TB-28	27%	52%	21%	13%	5.4%	11%
16	TB-34	22%	55%	24%	13%	5.2%	10%
20	TB-38	27%	49%	23%	14%	5.5%	11%
22	TB-43	22%	54%	24%	13%	5.2%	10%
6	TB-46	35%	43%	22%	15%	5.7%	12%
18	TB-51	25%	51%	24%	14%	5.4%	11%
11	TB-59	27%	50%	23%	14%	5.4%	11%
19	YS-13	23%	56%	21%	12%	5.2%	10%
7	YS-14	28%	51%	21%	14%	5.4%	11%
27	YS-19	21%	58%	21%	12%	5.2%	10%
			East Siberian Sea				
20	YS-22	19%	73%	7.8%	7.9%	4.2%	6.0%
16	YS-26	17%	76%	7.1%	7.3%	4.0%	5.5%
28	YS-28	17%	70%	13%	9.1%	4.5%	7.3%
9	YS-30	22%	69%	8.5%	8.7%	4.4%	6.6%
20	YS-31	22%	64%	14%	10%	4.9%	8.3%
10	YS-34B	32%	55%	13%	12%	5.1%	9.3%
32	YS-36	24%	56%	20%	12%	5.3%	10%
36	YS-38	23%	48%	29%	14%	5.2%	11%
49	YS-40	13%	46%	41%	10%	4.4%	8.5%
51	YS-93	14%	43%	43%	11%	4.5%	8.9%
45	YS-95	15%	54%	31%	11%	4.6%	9.0%
36	YS-116	12%	71%	16%	8.2%	4.2%	7.0%
33	YS-120	13%	63%	24%	9.3%	4.3%	7.9%
200	YS-86	4.8%	42%	53%	4.2%	3.8%	4.7%
63	YS-90	10%	36%	54%	7.8%	4.4%	7.1%
69	YS-102	5.3%	51%	44%	4.5%	3.5%	4.7%

Table S6 | Summary of coastal and shelf carbon fluxes in the East Siberian Arctic Shelf.

All values are in Tg OC, and reported as mean± 95% confidence intervals.

	Fraction of ICD-PF to OC input onto shelf		
	50%-50%	25%-75%	75%-25%
Burial on shelf[1]	20±8	20±8	20±8
Released onto shelf			
From coastal erosion	11±4	5.6±2	17±6
From seafloor erosion	11±4	17±6	5.6±2
Total	22±8	22±8	22±8
Degradation			
Released as CO_2 in shelf waters[2]	2.5±2	2.5±2	2.5±2
Released as CO_2 on coastal slopes[3]	22±8	11±4	32±12
Total	24±8	13±4	35±12
Annual thaw/erosion of Pleistocene carbon			
From coastal erosion	33±9	16±5	49±14
From seafloor erosion	11±4	17±6	5.6±2
Total	44±10	33±8	55±14

[1] Calculated according to: annual OC flux (36±17 gOC/m^2/yr; (mean±95% confidence interval)) x fraction accumulation bottoms (0.6; depth>30m where no resuspension occurs and pelite dominates) x average fraction ICD-OC (57±1.6%; (mean±95% confidence interval)). The total was multiplied by 1.6 to extrapolate to the entire ESAS, i.e. including the Laptev Sea.

[2] Annual POC degradation (mean±stdev) in the ESAS[41].

[3] Assuming 66±16% (mean±stdev) loss of ICD-OC onland as CO_2 (i.e. 34±16% is released as OC onto shelf)

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Table S7 | Elemental, isotopic and molecular composition of the Muostakh Island soil samples.

The concentration of terrestrial lipid biomarkers is expressed as mg/g OC. The $\delta^{13}C$ and ^{14}C age are measured relative to VPDB and Oxalic Acid I standards, respectively.

	Slope 2			Slope 5		Slope 6		Slope 7
	2-5	2-3	2-2	5-3	5-5	6-3	6-6	7-5
Bulk properties								
Profile height	13	16	18	1	24	2	23	23
Soil TOC (%)	0.69	1.0	3.5	0.74	1.5	1.1	3.3	2.5
TOC/TN	7.5	9.2	18	7.7	10	9.1	16	13
$\delta^{13}C$ (‰)	-23.9	-24.2	-28.8	-23.5	-24.3	-24.0	-27.0	-27.2
^{14}C age (kyrs)	17	16	5.1	26	15	20	9.4	35
$\Delta^{14}C$-OC (‰)	-885	-860	-474	-959	-854	-917	-691	-988
n-alkanes								
$HMW_{n\text{-alkanes}}$ [a]	0.86	0.77	3.3	0.69	0.91	0.64	2.7	14
CPI 21-31 [b]	7.0	6.7	3.9	3.2	3.0	11	7.1	4.0
$even{\leq}C_{20}/odd{\geq}C_{27}$ [c]	0.71	0.70	0.12	0.51	0.39	0.27	0.025	0.51
n-alkanoic acids								
$HMW_{n\text{-alkanoic acids}}$ [a]	1.6	3.0	23	0.76	2.8	11	7.0	6.3
CPI 20-30 [b]	4.1	6.7	5.9	4.0	4.7	7.2	4.4	3.0
$HMW_{n\text{-alkanoic acids}}/HMW_{n\text{-alkanes}}$	1.8	3.9	7.2	1.1	3.0	18	2.6	0.45
n-alkanols								
$HMW_{n\text{-alkanols}}$ [a]	1.1	3.2	31	0.31	0.31	1.4	6.6	11
CPI 20-30 [b]	14	15	6.6	9.3	6.3	18	27.	62
β-sitosterol [f] $/HMW_{n\text{-alkanes}}$	0	2.2	2.0	0	0	1.4	2.8	4.1

[a] HMW is high-molecular weight, sum of C_{20}-C_{34} for *n*-alkanes, sum of C_{20}-C_{30} for *n*-alkanoic acids and sum of C_{20}-C_{30} for *n*-alkanols.

[b] Calculated $CPI_{i\text{-}n}$, carbon preference index, $= \frac{1}{2}\ \Sigma(X_i+X_{i+2}+...+X_n)/\ \Sigma\ (X_{i-1}+X_{i+1}+...+X_{n-1}) + \frac{1}{2}\ \Sigma(X_i+X_{i+2}+...+X_n)/\ \Sigma(X_{i+1}+X_{i+3}+...+X_{n+1})$, where X is concentration.

[c] Even and low-molecular weight *n*-alkanes (C_{16}-C_{20}) to odd and high-molecular weight *n*-alkanes (C_{27}-C_{31}).

[f] 24-Ethylcholest-5-en-3β-ol.

Table S8 | CO_2 fluxes on Muostakh Island.

CO_2 fluxes (mmol/m^2/day) recorded along five slope transects (n=28) on Muostakh Island.

CO_2 transects	n	Lat (°N)	Long (°E)	CO_2 flux (mmol/m^2/day) mean	stdev
Transect 1	3	71.6125	129.9376	17	36
	3	71.6126	129.9378	3.2	0.5
	3	71.6129	129.9379	12	2.0
	3	71.6130	129.9379	4.0	2.6
	3	71.6130	129.9382	14	5.3
Transect 2	3	71.6124	129.9442	6.0	3.5
	3	71.6125	129.9442	4.9	1.0
	3	71.6126	129.9442	10	3.8
Transect 3	2	71.6093	129.9466	13	62
	2	71.6094	129.9469	12	4.3
	2	71.6096	129.9470	8.2	0.6
	2	71.6096	129.9473	15	11
	2	71.6096	129.9473	23	12
	2	71.6099	129.9509	18	0.6
	2	71.6104	129.9525	12	1.2
	2	71.6106	129.9533	28	8.6
	2	71.6108	129.9533	26	14
	2	71.6108	129.9533	5.2	0
	3	71.6104	129.9525	6.3	2.5
	3	71.6106	129.9533	18	3.6
	3	71.6108	129.9533	13	1.8
	3	71.6108	129.9533	17	2.2
	3	71.6106	129.9533	27	3.0
	3	71.6108	129.9533	4.0	1.3
	3	71.6108	129.9533	440	25
Transect 4	3	71.6101	129.9569	24	13
	1	71.6101	129.9568	48	0
Transect 5	3	71.6029	129.9799	110	30
	3	71.6029	129.9797	8.9	4.4
	3	71.6028	129.9796	17	9.7
	3	71.6027	129.9794	96	18
	3	71.6027	129.9792	9.2	4.9
	3	71.6025	129.9792	15	6.7
	3	71.6019	129.9753	27	8.7
	3	71.6014	129.9658	21	10
	3	71.6013	129.9653	220	71
	3	71.6014	129.9650	17	2.2

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Table S9 | Individual data for bulk geochemical data for surface sediments in the East Siberian Arctic Shelf.

For sediment OC and TOC/TN, outliers have been excluded (3 and 8 values respectively). Outliers (marked with *) are defined as observations farther than 1.5 x interquartile range from the closest quartile.

Year	Station	Lat (°N)	Long (°E)	Depth m	Sed.OC mg/gdw	stdev	$\delta^{13}C$ ‰	stdev	TOC/TN	$\Delta^{14}C$ ‰	error
2003	4	73.04	146.82	11	13.0	-	-25.1	-	15.1	-	-
2003	5	73.61	146.83	12	8.2	-	-24.6	-	14.4	-	-
2003	6	74.27	146.83	16.4	6.1	-	-24.4	-	13.1	-	-
2003	7	74.84	146.84	11	5.1	-	-23.8	-	16.3	-	-
2003	8	73.86	148.92	16	6.0	-	-24.0	-	14.8	-	-
2003	9	73.57	151.00	16	13.0	-	-24.5	-	21.4*	-	-
2003	10	72.92	151.00	15	6.7	-	-25.2	-	13.1	-	-
2003	11	72.00	150.99	9	17.9	-	-25.6	-	16.1	-	-
2003	12	71.63	152.49	14	20.4	-	-25.7	-	13.9	-	-
2003	13	71.24	153.99	14	18.9	-	-25.6	-	12.1	-	-
2003	14	71.62	154.99	15	11.3	-	-25.5	-	11.6	-	-
2003	15	71.99	155.99	17.5	11.2	-	-25.2	-	12.0	-	-
2003	16	71.66	157.34	12	12.7	-	-26.0	-	12.7	-	-
2003	17	71.43	158.90	14	10.6	-	-25.3	-	11.7	-	-
2003	18	71.00	159.89	10	13.0	-	-25.6	-	11.6	-	-
2003	19	70.43	161.20	10	6.9	-	-25.3	-	10.9	-	-
2003	20	70.00	161.20	11	12.4	-	-25.4	-	11.7	-	-
2003	21	70.33	162.49	9	11.1	-	-25.0	-	11.1	-	-
2003	22	70.72	163.99	11.2	3.9	-	-24.2	-	10.6	-	-
2003	23	70.43	166.99	25	10.1	-	-24.6	-	10.2	-	-
2003	24	70.15	172.15	31	14.5	-	-24.0	-	10.2	-	-
2003	25	70.01	176.31	38	15.3	-	-23.0	-	9.21	-	-
2003	26	69.92	176.07	11.8	11.0	-	-24.3	-	10.8	-	-
2003	27	70.24	177.16	50	17.2	-	-22.4	-	10.5	-	-
2003	28	70.48	178.00	50	14.9	-	-21.9	-	9.36	-	-
2003	29	70.67	178.47	42	11.2	-	-22.4	-	9.90	-	-
2003	30	70.48	171.99	35	9.3	-	-23.8	-	8.57	-	-
2003	31	70.85	167.99	41.6	16.0	-	-24.2	-	9.46	-	-
2003	32	70.63	164.99	18	8.7	-	-24.9	-	11.9	-	-
2003	33	71.12	161.99	20	8.7	-	-24.9	-	10.1	-	-
2003	34	72.49	154.00	29	13.6	-	-25.2	-	12.9	-	-
2003	35	72.59	151.00	15.5	10.2	-	-25.1	-	12.0	-	-
2003	36	72.97	148.34	10	14.8	-	-25.6	-	14.0	-	-
2003	43	73.02	143.14	12	8.9	-	-24.6	-	13.5	-	-
2004	25	73.14	134.64	18	5.5	-	-25.8	-	11.0	-	-
2004	27	73.85	137.16	22	16.2	-	-26.0	-	10.1	-	-
2004	29	74.76	140.00	9	7.0	-	-25.8	-	10.0	-	-
2004	30	74.49	140.23	27	20.8	-	-26.4	-	11.0	-	-
2004	31	74.33	140.38	10	10.0	-	-27.1	-	12.5	-	-

2004	36	74.80	146.50	14	11.0	-	-25.2	-	12.2	-	-
2004	37	74.16	146.67	15	10.2	-	-26.0	-	20.4*	-	-
2004	38	73.52	146.84	12	6.4	-	-26.3	-	10.7	-	-
2004	39	72.86	147.00	9	15.0	-	-27.3	-	13.6	-	-
2004	40	72.80	148.50	11	13.0	-	-27.0	-	11.8	-	-
2004	42	72.45	150.00	9	8.5	-	-27.1	-	12.1	-	-
2004	43	72.10	150.76	7	9.0	-	-27.0	-	12.9	-	-
2004	44	71.75	151.51	10	19.0	-	-27.4	-	12.7	-	-
2004	46	71.03	153.00	9	12.8	-	-26.8	-	11.6	-	-
2004	47	71.70	153.00	15	19.0	-	-26.9	-	11.2	-	-
2004	49	72.37	153.00	19	6.0	-	-26.0	-	10.0	-	-
2004	51	73.00	153.00	21	7.0	-	-25.6	-	10.0	-	-
2004	53	72.30	156.26	19	10.7	-	-26.3	-	10.7	-	-
2004	55	71.50	156.26	12.5	12.0	-	-26.6	-	10.0	-	-
2004	56	71.59	157.84	15	4.8	-	-26.1	-	9.60	-	-
2004	58	72.02	159.42	21	16.0	-	-28.3	-	13.3	-	-
2004	60	72.50	161.50	23	9.5	-	-25.9	-	8.64	-	-
2004	62	71.70	161.16	20	7.3	-	-25.9	-	8.11	-	-
2004	64	71.02	161.07	12	12.1	-	-26.1	-	9.31	-	-
2004	65	70.73	161.14	9	5.7	-	-26.0	-	9.50	-	-
2004	66	70.45	161.20	9.4	9.0	-	-26.3	-	1.00*	-	-
2004	67	70.17	161.27	9	37.3*	-	-25.6	-	124*	-	-
2004	68	69.83	161.35	9	18.0	-	-27.0	-	1.00*	-	-
2004	69	69.73	162.37	12	16.4	-	-27.3	-	14.9	-	-
2004	72	70.00	165.14	24	13.0	-	-26.0	-	9.29	-	-
2004	74	70.09	167.53	35	8.6	-	-25.2	-	8.60	-	-
2004	75	70.18	168.49	39	13.9	-	-26.0	-	10.7	-	-
2004	78	69.63	169.55	15	11.4	-	-25.3	-	10.4	-	-
2004	79	69.38	169.42	14	4.8	-	-24.4	-	8.00	-	-
2004	80	69.13	169.29	10	1.8	-	-24.4	-	9.00	-	-
2004	81	68.99	169.65	12	6.4	-	-26.9	-	12.8	-	-
2004	82	68.86	170.02	10.4	1.3	-	-25.0	-	13.0	-	-
2004	83	69.02	170.30	13	9.9	-	-26.7	-	12.4	-	-
2004	84	69.18	170.58	11	18.0	-	-26.9	-	12.9	-	-
2004	85	69.18	169.88	15	13.1	-	-26.1	-	10.1	-	-
2004	86	69.35	170.16	15.4	23.4	-	-26.4	-	10.2	-	-
2004	87	69.52	170.43	11	17.0	-	-27.0	-	12.1	-	-
2004	88	69.55	169.92	15.8	25.3	-	-26.5	-	9.73	-	-
2004	89	69.88	169.77	16	10.0	-	-25.8	-	10.0	-	-
2004	91	70.21	170.39	31	20.1	-	-25.8	-	9.14	-	-
2004	95	69.96	176.11	22	20.5	-	-24.2	-	0.86*	-	-
2004	96	70.10	176.63	46	12.6	-	-23.6	-	0.88*	-	-
2004	97	70.27	177.20	50	18.6	-	-23.1	-	7.75	-	-
2004	99	70.42	177.78	47.8	21.9	-	-22.9	-	7.55	-	-
2004	100	70.58	178.29	47.2	17.4	-	-22.8	-	7.57	-	-
2004	101	70.74	178.66	30	13.8	-	-24.2	-	7.67	-	-
2004	102	70.51	177.57	44	19.7	-	-22.9	-	6.35	-	-
2004	103	70.50	176.10	45	18.7	-	-23.4	-	6.45	-	-
2004	104	70.50	174.63	41.6	12.6	-	-23.9	-	7.88	-	-

2004	105	70.48	173.13	37.2	14.6	-	-24.3	-	7.68	-	-
2004	106	70.48	171.60	30.8	16.3	-	-24.9	-	7.41	-	-
2004	107	70.48	170.12	26	16.1	-	-25.4	-	7.67	-	-
2004	108	70.46	168.62	28	19.6	-	-25.4	-	7.26	-	-
2004	110	70.83	162.88	17.6	4.9	-	-25.5	-	8.17	-	-
2004	111	73.43	155.08	34.2	10.3	-	-25.1	-	7.92	-	-
2004	112	74.14	153.31	18.4	8.2	-	-25.1	-	8.20	-	-
2004	113	74.56	153.43	14.4	9.4	-	-25.0	-	9.40	-	-
2004	114	75.00	153.53	16	6.6	-	-25.2	-	9.43	-	-
2007	TB-01	74.84	129.04	41	13.1	0.3	-25.4	0.1	8.73	-	-
2007	TB-02	74.83	130.01	37	16.8	0.2	-25.7	0.1	8.40	-	-
2007	TB-03	74.84	131.00	28	14.8	0.4	-25.7	0.2	9.87	-	-
2007	TB-04	74.59	130.99	27	6.1	0.3	-25.6	0.1	15.3	-	-
2007	TB-05	74.59	130.02	32	15.2	0.1	-25.7	0.1	10.9	-	-
2007	TB-06	74.59	129.03	26	11.3	0.5	-25.6	0.1	10.3	-	-
2007	TB-07	74.33	128.99	19	0.5	0.1	-26.1	1.3	5.00	-	-
2007	TB-08	74.33	130.03	22	1.0	0.1	-24.9	0.5	10.0	-	-
2007	TB-09	74.34	131.00	26	3.9	0.2	-25.7	0.1	13.0	-	-
2007	TB-10	74.08	130.99	24	2.1	1.3	-26	0.8	10.5	-	-
2007	TB-11	74.08	130.01	15.5	1.7	0.3	-25.9	0.7	8.50	-	-
2007	TB-12	74.08	129.00	16	0.5	0.1	-25.1	0.3	5.00	-	-
2007	TB-13	73.83	129.00	16	0.3	0.2	-25.1	1.1	3.00	-	-
2007	TB-14	73.83	130.00	19	3.0	0.2	-25.7	0.2	15.0	-	-
2007	TB-15	73.83	131.00	20	1.9	0.1	-25.5	0.4	9.50	-	-
2007	TB-16	73.58	130.99	20	16.5	0.3	-25.4	0.1	9.17	-	-
2007	TB-17	73.58	130.00	14	0.9	0.2	-25.7	0.7	9.00	-	-
2007	TB-18	73.58	129.00	21	19.2	0.4	-26.2	0.1	12.0	-	-
2007	TB-19	73.33	130.14	25	13.6	0.3	-25.9	0.1	11.3	-	-
2007	TB-20	73.32	131.00	25	18.5	0.1	-25.8	0.1	9.74	-	-
2008	4	75.99	129.98	50	13.4	-	-24.3	-	8.03	-437	3
2008	6	74.72	130.02	32	18.6	-	-25.6	-	9.46	-465	3
2008	13	71.97	131.70	19	18.9	-	-25.9	-	10.7	-543	2
2008	14	71.63	130.05	7	19.1	-	-26.2	-	13.9	-504	2
2008	19	73.11	137.30	27	18.2	-	-25.8	-	10.0	-557	3
2008	20	73.31	139.89	8	3.9	0.1	-26.9	0.1	6.93	-	-
2008	21	73.09	140.35	15	8.1	0.2	-27.0	0.1	8.20	-	-
2008	22	72.88	140.63	20	11.8	0.3	-27.4	0.2	9.28	-716	3
2008	23	72.79	142.67	10	9.1	1.5	-27.2	0.1	8.86	-	-
2008	24	73.05	142.67	15	7.7	0.3	-27.4	0.1	9.02	-	-
2008	25	73.14	142.67	10	10.2	0.3	-27.3	0.1	8.91	-	-
2008	26	72.46	150.60	16	8.7	0.2	-27.4	0.1	8.42	-741	2
2008	27	72.57	152.37	18	4.1	0.1	-26.2	0.2	6.88	-	-
2008	28	72.65	154.19	28	8.7	0.1	-26.2	0.1	6.94	-672	2
2008	29	72.20	153.17	18	6.3	0.3	-26.6	0.1	7.83	-	-
2008	30	71.36	152.15	9	13.5	0.2	-27.4	0.1	8.85	-682	2
2008	31	71.59	161.69	20	5.6	0.1	-26.5	0.1	6.60	-624	4
2008	32	70.57	161.22	9	4.2	0.2	-26.4	0.1	6.60	-	-
2008	33	70.17	161.22	8	4.0	0.5	-26.2	0.2	6.48	-	-
2008	35	69.82	164.06	31	12.2	3.4	-26.8	0.5	8.93	-	-

2008	36	69.82	166.00	32	8.0	0.1	-26.0	0.1	6.80	-547	2
2008	37	70.13	168.01	42	9.4	0.4	-25.7	0.1	6.67	-	-
2008	38	70.70	169.13	36	10.0	0.1	-25.3	0.2	6.47	-462	3
2008	39	71.22	169.37	44	12.3	0.1	-24.3	0.2	6.12	-	-
2008	40	71.48	170.55	49	13.6	0.3	-23.9	0.1	6.17	-425	3
2008	41	71.97	171.79	43	13.2	0.3	-23.9	0.2	6.08	-	-
2008	86	75.30	174.40	200	8.9	0.2	-21.2	0.1	5.24	-391	3
2008	88	75.10	172.19	142	10.4	0.1	-21.5	0.1	5.48	-	-
2008	90	74.67	172.39	63	8.5	0.1	-22.4	0.1	5.62	-332	3
2008	91	74.43	170.85	56	8.2	0.2	-23.3	0.2	5.64	-	-
2008	93	74.42	166.00	51	8.0	0.1	-23.8	0.1	5.45	-398	3
2008	95	74.42	161.34	45	9.7	0.4	-24.8	0.1	5.72	-511	3
2008	97	75.27	160.89	49	8.5	0.1	-24.1	0.1	5.53	-	-
2008	98	75.55	160.75	48	7.7	0.1	-23.9	0.1	5.43	-	-
2008	99	75.17	163.59	50	7.7	0.1	-23.4	0.1	5.45	-	-
2008	100	75.72	164.08	58	7.6	0.1	-22.4	0.1	5.76	-	-
2008	102	76.56	160.07	69	7.7	0.1	-22.3	0.2	5.51	-476	3
2008	104	76.93	155.17	57	9.1	0.1	-23.1	0.1	5.85	-	-
2008	106	76.97	150.29	43	8.7	0.1	-23.8	0.1	6.06	-	-
2008	111	75.00	160.01	46	8.0	0.1	-24.2	0.2	5.94	-	-
2008	112	74.83	159.33	42	8.8	0.1	-24.6	0.1	6.17	-	-
2008	116	74.58	157.00	36	6.0	0.1	-25.5	0.2	6.63	-682	2
2008	118	74.33	156.01	28	7.1	0.1	-25.2	0.1	6.79	-	-
2008	120	73.29	155.17	33	9.9	0.1	-25.0	0.2	6.70	-600	2
2008	131	76.40	125.47	50	4.0	0.1	-24.3	0.2	6.62	-	-
2008	22B	72.89	140.62	15	10.7	1.1	-27.4	0.1	9.51	-	-
2008	34B	69.71	162.69	10	11.2	0.3	-27.3	0.2	9.96	-554	2
2008	TB-17	72.29	132.92	21	15.1	-	-25.6	-	9.94	-	-
2008	TB-18	72.17	133.00	16	8.0	0.08	-25.7	0.23	10.5	-	-
2008	TB-19	72.09	132.78	14	4.7	-	-26.0	-	11.2	-622	3
2008	TB-22	71.88	132.11	15	3.2	0.04	-25.2	0.28	9.44	-	-
2008	TB-23	71.83	131.67	20	15.9	-	-25.8	-	10.0	-	-
2008	TB-24	71.76	131.17	16	18.7	-	-25.6	-	10.3	-549	2
2008	TB-25	71.72	130.83	13	18.8	-	-25.8	-	10.6	-	-
2008	TB-26	71.69	130.58	12.5	20.9	-	-25.8	-	12.2	-	-
2008	TB-27	71.66	130.33	10.6	18.6	0.02	-25.9	0.08	13.1	-	-
2008	TB-28	71.62	130.04	5.3	21.5	-	-26.2	-	14.6	-513	3
2008	TB-30	71.87	129.83	5	20.4	-	-26.0	-	14.9	-	-
2008	TB-31	71.86	130.32	12	22.5	-	-25.9	-	12.1	-	-
2008	TB-32	71.86	131.09	12	18.4	0.01	-25.6	0.02	10.5	-	-
2008	TB-33	72.09	131.09	14.5	21.9	0.02	-25.8	0.13	11.0	-	-
2008	TB-34	72.29	131.09	16	18.5	0.02	-25.7	0.05	11.8	-526	3
2008	TB-35	72.46	131.09	16.5	22.2	0.01	-25.9	0.07	11.9	-	-
2008	TB-36	72.59	131.10	17	21.2	-	-25.9	-	12.1	-	-
2008	TB-37	72.71	131.09	18.5	23.9	-	-26.0	-	12.4	-	-
2008	TB-38	72.93	130.84	20	23.5	-	-26.0	-	12.3	-482	3
2008	TB-39	72.93	130.66	20	23.0	-	-25.9	-	13.3	-	-
2008	TB-40	72.93	130.03	6	15.0	-	-26.0	-	13.1	-	-
2008	TB-43	72.89	131.93	21.8	15.6	-	-25.6	-	10.3	-517	2

2008	TB-44	72.71	131.66	18.8	20.9	-	-25.9	-	11.4	-	-
2008	TB-45	72.70	130.66	15	22.4	-	-25.9	-	12.4	-	-
2008	TB-46	72.70	130.18	6	25.8	-	-26.5	-	14.3	-436	2
2008	TB-48	72.59	130.12	6.5	38.1*	-	-26.6	-	16.2*	-	-
2008	TB-49	72.59	130.68	14	20.2	-	-25.8	-	12.5	-	-
2008	TB-50	72.59	131.66	18	18.2	-	-25.7	-	11.4	-	-
2008	TB-51	72.46	131.66	18	21.4	-	-25.8	-	11.3	-495	4
2008	TB-52	72.45	130.67	12.5	13.4	-	-25.8	-	11.6	-	-
2008	TB-53	72.28	130.07	8.5	95.1*	1.42	-27.5	0.09	23.2*	-	-
2008	TB-54	72.28	130.59	10	8.8	-	-25.7	-	11.7	-	-
2008	TB-55	72.29	131.72	17	19.7	-	-25.8	-	11.1	-	-
2008	TB-56	72.10	131.72	15	18.0	-	-25.7	-	10.4	-	-
2008	TB-57	72.00	131.77	10	18.3	-	-25.7	-	10.5	-	-
2008	TB-59	72.09	130.06	11	18.7	-	-26.0	-	12.7	-493	3

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Table S10 | Raw radiochronological data for East Siberian Arctic Shelf sediment cores.

slice interval	^{210}Pb		^{226}Ra		$^{210}Pb_{xs}$		porosity	Dry density		$^{210}Pb_{xs}$	
cm	Bq/gdw	stdev	Bq/gdw	stdev	Bq/gdw	stdev		g/cm^3	stdev	Bq/m^2	stdev
YS-22											
0-1	0.051	0.003	0.022	0.002	0.029	0.004	0.39	2.7	0.36	484	87
1-2	0.056	0.004	0.030	0.002	0.026	0.004	0.36	2.7	0.36	451	97
2-3	0.054	0.004	0.025	0.002	0.029	0.005	0.34	2.7	0.36	520	110
3-4	0.060	0.003	0.021	0.002	0.039	0.003	0.32	2.7	0.36	721	110
4-5	0.074	0.005	0.022	0.003	0.052	0.005	0.34	2.7	0.36	931	160
5-6	0.052	0.005	0.026	0.003	0.026	0.005	0.36	2.7	0.36	453	110
6-7	0.051	0.003	0.023	0.002	0.028	0.003	0.35	2.7	0.36	485	85
7-8	0.066	0.004	0.028	0.002	0.038	0.004	0.34	2.7	0.36	680	120
8-9	0.065	0.003	0.027	0.002	0.039	0.004	0.37	2.7	0.36	654	110
9-10	0.054	0.004	0.025	0.002	0.029	0.004	0.34	2.7	0.36	515	110
10-11	0.054	0.004	0.002	0.002	0.052	0.004	0.33	2.7	0.36	929	150
11-12	0.054	0.003	0.026	0.002	0.029	0.004	0.28	2.7	0.36	553	100
12-13	0.068	0.004	0.012	0.002	0.057	0.004	0.29	2.7	0.36	1090	170
13-14	0.072	0.004	0.023	0.002	0.049	0.005	0.37	2.7	0.36	832	140
14-15	0.078	0.004	0.028	0.002	0.049	0.004	0.42	2.7	0.36	776	120
YS-26											
0-1	0.071	0.005	0.035	0.003	0.036	0.006	0.56	2.7	0.36	432	90
1-2	0.062	0.004	0.036	0.003	0.026	0.005	0.45	2.7	0.36	386	86
2-3	0.039	0.003	0.037	0.002	0.003	0.003	0.33	2.7	0.36	46.6	62
3-4	0.063	0.005	0.015	0.003	0.048	0.003	0.38	2.7	0.36	804	140
4-5	0.058	0.004	0.018	0.003	0.040	0.005	0.43	2.7	0.36	614	120
5-6	0.067	0.005	0.036	0.003	0.030	0.006	0.45	2.7	0.36	453	110
6-7	0.054	0.003	0.021	0.002	0.033	0.004	0.40	2.7	0.36	531	93
7-8	0.039	0.003	0.018	0.002	0.021	0.004	0.31	2.7	0.36	399	92
8-9	0.053	0.004	0.023	0.003	0.030	0.005	0.36	2.7	0.36	518	110
9-10	0.062	0.003	0.023	0.002	0.039	0.003	0.37	2.7	0.36	653	100
10-11	0.046	0.003	0.026	0.002	0.020	0.004	0.34	2.7	0.36	350	83
11-12	0.043	0.003	0.033	0.002	0.011	0.004	0.33	2.7	0.36	191	75
12-13	0.053	0.003	0.046	0.002	0.008	0.004	0.34	2.7	0.36	137	77
13-14	0.053	0.003	0.041	0.002	0.012	0.003	0.32	2.7	0.36	217	65
YS-35											
0-1	0.052	0.004	0.023	0.001	0.030	0.004	0.44	2.7	0.36	443	88
1-2	0.033	0.004	0.020	0.001	0.013	0.004	0.36	2.7	0.36	218	80
2-3	0.035	0.002	0.022	0.001	0.012	0.002	0.35	2.7	0.36	214	49
3-4	0.037	0.003	0.026	0.001	0.011	0.004	0.35	2.7	0.36	189	69
4-5	0.028	0.004	0.027	0.001	0.001	0.004	0.34	2.7	0.36	23.7	79
5-6	0.027	0.004	0.024	0.001	0.003	0.005	0.29	2.7	0.36	61.7	91
6-7	0.028	0.002	0.027	0.001	0.001	0.002	0.29	2.7	0.36	12.3	37
7-8	0.032	0.004	0.027	0.001	0.004	0.004	0.32	2.7	0.36	81.4	75
8-9	0.030	0.004	0.036	0.001	0	0.004	0.35	2.7	0.36	0	0
9-10	0.032	0.004	0.036	0.001	0	0.005	0.32	2.7	0.36	0	0
10-11	0.030	0.002	0.035	0.001	0	0.002	0.26	2.7	0.36	0	0

YS-36											
0-1	0.044	0.004	0.028	0.002	0.016	0.004	0.54	2.7	0.36	200	57
1-2	0.054	0.004	0.026	0.001	0.028	0.004	0.47	2.7	0.36	403	79
2-3	0.044	0.004	0.023	0.001	0.021	0.004	0.43	2.7	0.36	317	79
3-4	0.039	0.003	0.026	0.001	0.013	0.003	0.41	2.7	0.36	208	63
4-5	0.041	0.004	0.032	0.001	0.010	0.004	0.39	2.7	0.36	158	69
5-6	0.036	0.004	0.031	0.001	0.006	0.004	0.36	2.7	0.36	98.9	74
6-7	0.041	0.003	0.033	0.001	0.009	0.003	0.34	2.7	0.36	153	53
7-8	0.034	0.003	0.032	0.001	0.002	0.003	0.33	2.7	0.36	35.7	58
8-9	0.030	0.004	0.026	0.001	0.004	0.004	0.32	2.7	0.36	70.0	68
9-10	0.022	0.003	0.027	0.001	0	0.003	0.32	2.7	0.36	0	0
10-11	0.030	0.002	0.028	0.001	0.001	0.002	0.31	2.7	0.36	0	0
11-12	0.027	0.004	0.029	0.001	0	0.004	0.31	2.7	0.36	0	0
12-13	0.026	0.002	0.027	0.001	0	0.002	0.31	2.7	0.36	0	0
13-14	0.024	0.004	0.027	0.001	0	0.004	0.29	2.7	0.36	0	0
YS-37											
0-1	0.060	0.004	0.027	0.002	0.033	0.005	0.62	2.7	0.36	336	64
1-2	0.064	0.003	0.023	0.001	0.041	0.003	0.57	2.7	0.36	479	73
2-3	0.063	0.003	0.023	0.001	0.040	0.004	0.54	2.7	0.36	491	78
3-4	0.056	0.005	0.031	0.002	0.025	0.005	0.53	2.7	0.36	312	74
4-5	0.049	0.005	0.024	0.001	0.026	0.005	0.51	2.7	0.36	339	80
5-6	0.053	0.004	0.020	0.001	0.032	0.005	0.46	2.7	0.36	478	93
6-7	0.045	0.002	0.024	0.001	0.021	0.003	0.43	2.7	0.36	331	60
7-8	0.037	0.004	0.027	0.002	0.011	0.004	0.43	2.7	0.36	162	72
8-9	0.040	0.004	0.024	0.001	0.016	0.004	0.39	2.7	0.36	261	77
9-10	0.036	0.002	0.025	0.001	0.011	0.002	0.36	2.7	0.36	189	48
10-11	0.037	0.003	0.027	0.001	0.010	0.003	0.36	2.7	0.36	179	62
11-12	0.027	0.005	0.024	0.001	0.003	0.005	0.35	2.7	0.36	44.3	82
12-13	0.036	0.005	0.022	0.002	0.014	0.005	0.36	2.7	0.36	239	93
13-14	0.033	0.003	0.026	0.001	0.007	0.003	0.36	2.7	0.36	116	50
14-15	0.028	0.004	0.028	0.002	0.001	0.004	0.37	2.7	0.36	10.6	68
YS-90											
0-1	0.074	0.01	0.027	0.002	0.048	0.011	0.76	2.7	0.36	315	82
1-2	0.053	0.01	0.029	0.001	0.024	0.008	0.66	2.7	0.36	222	77
2-3	0.052	0.01	0.031	0.001	0.021	0.008	0.61	2.7	0.36	225	90
3-4	0.048	0.01	0.030	0.001	0.018	0.008	0.58	2.7	0.36	206	96
4-5	0.039	0.01	0.027	0.001	0.012	0.007	0.55	2.7	0.36	141	91
5-6	0.035	0.004	0.024	0.001	0.011	0.004	0.53	2.7	0.36	135	58
6-7	0.040	0.01	0.025	0.001	0.015	0.007	0.50	2.7	0.36	204	100
7-8	0.032	0.01	0.025	0.001	0.007	0.007	0.44	2.7	0.36	108	100
8-9	0.028	0.01	0.023	0.001	0.006	0.006	0.39	2.7	0.36	92.7	110
9-10	0.020	0.01	0.025	0.001	0	0.007	0.37	2.7	0.36	0	0
10-11	0.024	0.01	0.024	0.001	0.000	0.006	0.36	2.7	0.36	0	0
11-12	0.024	0.01	0.023	0.001	0.001	0.007	0.37	2.7	0.36	0	0
12-13	0.021	0.01	0.024	0.001	0	0.006	0.34	2.7	0.36	0	0
13-14	0.019	0.01	0.022	0.001	0	0.007	0.35	2.7	0.36	0	0
14-15	0.020	0.004	0.022	0.001	0	0.004	0.34	2.7	0.36	0	0
15-16	0.021	0.01	0.022	0.001	0	0.006	0.35	2.7	0.36	0	0

16-17	0.025	0.01	0.023	0.001	0.001	0.007	0.36	2.7	0.36	0	0
YS-93											
0-1	0.109	0.004	0.070	0.003	0.038	0.005	0.71	2.7	0.36	297	55
1-2	0.113	0.005	0.056	0.003	0.057	0.006	0.63	2.7	0.36	574	96
2-3	0.101	0.003	0.056	0.002	0.045	0.004	0.59	2.7	0.36	502	78
3-4	0.092	0.004	0.049	0.003	0.043	0.005	0.58	2.7	0.36	486	83
4-5	0.076	0.006	0.038	0.004	0.038	0.007	0.53	2.7	0.36	479	110
5-6	0.082	0.005	0.048	0.003	0.034	0.006	0.49	2.7	0.36	468	100
6-7	0.055	0.003	0.055	0.002	0	0.004	0.46	2.7	0.36	2.66	55
7-8	0.061	0.005	0.039	0.004	0.022	0.006	0.46	2.7	0.36	316	100
8-9	0.065	0.003	0.045	0.002	0.020	0.004	0.45	2.7	0.36	295	74
9-10	0.061	0.005	0.035	0.004	0.026	0.007	0.44	2.7	0.36	393	120
10-11	0.053	0.005	0.037	0.003	0.016	0.006	0.43	2.7	0.36	252	92
11-12	0.046	0.004	0.039	0.002	0.007	0.004	0.42	2.7	0.36	104	68
12-13	0.057	0.004	0.050	0.003	0.008	0.005	0.41	2.7	0.36	125	74
13-14	0.057	0.003	0.043	0.002	0.014	0.004	0.42	2.7	0.36	218	63
YS-98											
0-1	0.046	0.02	0.024	0.006	0.022	0.016	0.92	2.7	0.36	44.6	34
1-2	0.086	0.01	0.039	0.002	0.046	0.008	0.67	2.7	0.36	408	87
2-3	0.083	0.00	0.046	0.002	0.037	0.005	0.58	2.7	0.36	415	77
3-4	0.073	0.01	0.040	0.002	0.034	0.007	0.54	2.7	0.36	423	110
4-5	0.061	0.01	0.038	0.003	0.024	0.007	0.52	2.7	0.36	307	100
5-6	0.080	0.01	0.039	0.002	0.041	0.007	0.47	2.7	0.36	588	130
6-7	0.037	0.01	0.033	0.002	0.004	0.007	0.44	2.7	0.36	55.2	110
7-8	0.043	0.00	0.032	0.001	0.011	0.004	0.43	2.7	0.36	169	72
8-9	0.043	0.01	0.028	0.002	0.015	0.007	0.41	2.7	0.36	235	120
9-10	0.032	0.01	0.030	0.002	0.003	0.008	0.42	2.7	0.36	41.2	120
10-11	0.039	0.00	0.032	0.001	0.007	0.004	0.41	2.7	0.36	114	72
11-12	0.032	0.01	0.032	0.003	0.000	0.007	0.40	2.7	0.36	0	110
YS-120											
0-1	0.117	0.007	0.040	0.003	0.076	0.007	0.71	2.7	0.36	608	99
1-2	0.133	0.005	0.044	0.001	0.089	0.005	0.64	2.7	0.36	860	130
2-3	0.120	0.005	0.043	0.001	0.076	0.005	0.61	2.7	0.36	807	120
3-4	0.109	0.003	0.051	0.001	0.058	0.003	0.60	2.7	0.36	632	91
4-5	0.112	0.007	0.054	0.002	0.059	0.008	0.59	2.7	0.36	645	120
5-6	0.121	0.008	0.051	0.003	0.070	0.008	0.60	2.7	0.36	764	130
6-7	0.121	0.008	0.049	0.002	0.072	0.008	0.60	2.7	0.36	783	140
7-8	0.124	0.005	0.054	0.002	0.069	0.005	0.59	2.7	0.36	761	120
8-9	0.127	0.007	0.060	0.003	0.067	0.008	0.58	2.7	0.36	766	140
9-10	0.126	0.007	0.060	0.002	0.067	0.008	0.55	2.7	0.36	811	140
10-11	0.102	0.008	0.057	0.002	0.044	0.008	0.51	2.7	0.36	583	130
IK-105[1]											
0-1	0.194	0.014	0.060	0.010	0.134	0.017	0.7	2.7	0.36	1090	200
2-3	0.061	0.011	0.035	0.007	0.026	0.013	0.6	2.7	0.36	285	140
4-5	0.068	0.013	0.041	0.012	0.027	0.018	0.6	2.7	0.36	289	200
5-6	0.096	0.006	0.005	0.004	0.091	0.007	0.6	2.7	0.36	981	150
6-7	0.071	0.013	0.025	0.008	0.046	0.015	0.6	2.7	0.36	496	170
9-10	0.053	0.015	0.034	0.009	0.019	0.017	0.6	2.7	0.36	202	190

14-15	0.060	0.007	0.006	0.005	0.054	0.009	0.6	2.7	0.36	588	120
16-17	0.038	0.011	0.053	0.008	0	0.013	0.6	2.7	0.36	0	0
24-25	0.067	0.008	0.020	0.006	0.047	0.009	0.6	2.7	0.36	504	120
IK-110											
0-1	0.013	0.005	0.003	0.004	0.010	0.006	0.7	2.7	0.36	80.8	49
1-2	0.010	0.004	0.017	0.004	0	0.006	0.6	2.7	0.36	0	0
2-3	0.027	0.004	0.033	0.004	0	0.006	0.6	2.7	0.36	0	0
3-4	0.017	0.003	0.035	0.002	0	0.004	0.6	2.7	0.36	0	0
4-5	0.038	0.006	0.009	0.005	0.029	0.008	0.6	2.7	0.36	312	97
6-7	0.023	0.004	0.011	0.004	0.012	0.005	0.6	2.7	0.36	128	60
7-8	0.000	0.004	0.013	0.004	0	0.005	0.6	2.7	0.36	0	0
12-13	0.002	0.004	0.022	0.004	0	0.006	0.6	2.7	0.36	0	0
IK-114											
0-5	0.028	0.003	0.019	0.003	0.009	0.004	0.7	2.7	0.36	72.8	31
9-15	0.031	0.003	0.018	0.003	0.013	0.004	0.6	2.7	0.36	140	47
10-15	0.031	0.003	0.022	0.004	0.009	0.005	0.6	2.7	0.36	100	53
15-22	0.032	0.002	0.018	0.002	0.015	0.003	0.6	2.7	0.36	157	36
20-25	0.027	0.001	0.024	0.001	0.002	0.002	0.6	2.7	0.36	23.2	21
27-30	0.030	0.002	0.019	0.001	0.011	0.002	0.6	2.7	0.36	114	28
30-35	0.031	0.002	0.025	0.001	0.006	0.002	0.6	2.7	0.36	67.2	25
35-40	0.032	0.002	0.016	0.001	0.016	0.003	0.6	2.7	0.36	170	36
IK-118											
0-5.5	0.125	0.009	0.067	0.009	0.058	0.013	0.7	2.7	0.36	473	120
5-10	0.131	0.010	0.030	0.008	0.101	0.013	0.6	2.7	0.36	1090	200
10-15	0.052	0.007	0.062	0.007	0	0.010	0.6	2.7	0.36	0	0
15-20	0.044	0.007	0.000	0.000	0.044	0.007	0.6	2.7	0.36	480	98
20-25	0.066	0.008	0.013	0.009	0.054	0.012	0.6	2.7	0.36	578	160
25-30	0.070	0.012	0.046	0.013	0.023	0.018	0.6	2.7	0.36	250	190
30-35	0.099	0.012	0.047	0.011	0.052	0.017	0.6	2.7	0.36	558	190
35-40	0.061	0.004	0.000	0.000	0.061	0.004	0.6	2.7	0.36	662	99
40-45	0.074	0.009	0.020	0.009	0.055	0.012	0.6	2.7	0.36	589	160
45-50	0.073	0.005	0.028	0.005	0.045	0.007	0.6	2.7	0.36	488	100
50-55	0.113	0.005	0.051	0.006	0.063	0.008	0.6	2.7	0.36	679	120
55-58	0.069	0.008	0.025	0.006	0.044	0.010	0.6	2.7	0.36	476	130

[1] Only 9cm of the 25cm core has been counted, so a correction factor of 2.8 has been used when calculating the total $^{210}Pb_{xs}$ (Bq/m^2/yr).