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Mobilization of old terrestrial carbon caused by permafrost thawing, sea-level rise and ice-sheet melting during the last deglaciation

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The last deglaciation was characterized by rising concentrations in atmospheric CO_2 (CO_2atm) and a decrease in its radiocarbon content (Δ14Catm). Mobilization of 14C-depleted terrestrial organic carbon, which was previously frozen in extensive boreal permafrost soils, might have contributed to both changes. Since parts of this potentially mobilized organic carbon was reburied in marine sediments, records of accumulation of terrigenous biomarkers and their compound-specific radiocarbon ages can provide insights into the timing of, and controls on permafrost decomposition. We present data from marine sediment cores covering the last deglaciation that were retrieved from key locations potentially receiving terrigenous material mobilized from hotspot areas of permafrost thaw. In the North Pacific, we studied two cores off the Amur River draining into the Okhotsk Sea, and one core from the Northeastern Bering Sea adjacent to the Bering shelf (one of the largest shelf areas flooded during the deglaciation), which receives input from the Yukon River. During the Last Glacial Maximum these catchments were completely covered with permafrost. Today, the Amur drainage basin is free of permafrost while the Yukon catchment is covered by discontinuous permafrost. Besides, we investigated one core from the northwestern Black Sea as a record of terrigenous material released from the thawing European tundra. All sites show distinct deglacial maxima in accumulation of old terrigenous biomarkers (5-20 kyr old at the time of deposition). In the Black Sea, one early maximum of terrigenous organic matter accumulation occurred during HS1. In the North Pacific region, two more pronounced maxima occurred later during meltwater pulses suggesting that sea-level rise remobilized old terrestrial carbon from permafrost on the flooded shelfs. Sea-level rise thus likely caused abrupt decomposition events across the Okhotsk and Bering Shelfs. We extrapolate our localized findings to an overall potential carbon release during deglaciation of 285 Pg C from coastal erosion in the Arctic Ocean and the related permafrost decomposition. By analysing some idealized scenarios using the global carbon cycle model BICYCLE we estimate the impact of carbon release from thawing permafrost on the atmosphere. We find that it might have accounted for a deglacial rise in CO_2atm of up to 15 ppm, and to a decline in Δ14Catm of 15‰. These results, if restricted to the three peak events as supported by our data, might have contributed particularly to abrupt changes in CO_2atm and Δ14Catm, corresponding to 15-20% of both, the observed rise in CO_2atm of ∼90 ppm, and the residual in Δ14Catm that is unexplained by changes in the 14C production rate.