The hidden age of carbon released by peatlands

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Radiocarbon (^{14}C) is a key tracer for detecting the mobilization of previously stored terrestrial organic C into aquatic systems. But despite the presence of substantial old organic C (C >1,000 y B.P.) in peatland catchments, the ^{14}C age of dissolved organic C (DOC) in peatland streams (the main form of lateral C export in these systems) is predominantly modern. Old C may be 'masked' by post-bomb C (fixed from the atmosphere post-AD1950), potentially rendering bulk aquatic DO^{14}C measurements insensitive to old C. We investigate this with (1) a laboratory and (2) a field approach measuring natural abundance ^{14}C of DOC, carbon dioxide (CO_2) and methane (CH_4).

(1) We collected DOC with a modern ^{14}C signature from a temperate Scottish peatland stream and decomposed it to produce CO_2 under simulated natural conditions over 140 days. We measured the ^{14}C of both DOC and CO_2 at seven time-points and found that while DOC remained close to modern in age, the resultant CO_2 was up to 2,350 y B.P. This demonstrates that bulk DO^{14}C ages can hide the presence of old C within aquatic DOC export, potentially making this approach an insensitive indicator of disturbance.

(2) We also measured directly the ^{14}C content of aquatic CO_2 and CH_4, alongside DOC and particulate-OC, in freshwater systems of the Canadian and Siberian Arctic tundra – the first such concurrent ^{14}C measurements from freshwater systems. Modern C (assimilated since AD1950) appeared to dominate aquatic CO_2 and CH_4 emissions, except where deep ancient (6,000 to ~50,000 yBP) C was exposed. Age distribution modeling indicated that 'pre-industrial' C (assimilated prior to ~AD1750) comprised 15-40% of aquatic carbon export.

These results demonstrate the presence of 'hidden' aged C within peatland aquatic export. They also suggest that greater amounts of old C may be released into peatland aquatic systems than was previously thought, which has implications for tracing and modeling interactions between the hydrological and terrestrial C cycles.