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Centennial-scale variations in abundance and sources of black carbon aerosols as recorded in two lake sediment cores from NE USA and N. Europe

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Black carbon (BC) aerosols are important agents of anthropogenic climate forcing. Detailed historical records of environmental/atmospheric loadings of BC are useful for several lines of investigations, including to parameterize hindcast climate modeling and to assess the success of various strategies toward mitigation of aerosol emissions. Here, we report on two detailed BC records in radiochronologically-constrained lake sediment cores from NE USA (Upper Mystic Lake, a recreational lake in today's suburban Boston, MA, USA) and N. Europe (Stora Frilligen Lake, a rural lake 100 km south of Stockholm, Sweden and near the EMEP-Aspvreten air monitoring station).

Both lakes have small drainage basins, are located in close proximity to industrialized cities, and hold deep layers of water that have rarely mixed with the top waters, thus the highly anoxic sediments at the bottom accumulated in annual layers and have been nearly undisturbed for a thousand years. Both sediment cores had high porosity and similar density, but the sedimentation rate determined in the Mystic core was five times the Apsvreten core (10 and 2 mm yr-1, respectively).

Historical trends in BC sediment flux (g cm-2 yr-1) were studied as opposed to historical BC concentration (mg g-1) as the former is closer linked to atmospheric loadings and washouts, and is independent of other major/detrital matrix constituents. Previous studies have defined characteristics of each lake used for BC sediment flux calculations. The dilute sedimentary BC flux range in the Mystic core was 7 to 21 (g m-2 yr-1). In the Aspvreten core BC sediment flux was found in the range of < 0.01 to 0.4 (g m-2 yr-1). While there exists a greater flux magnitude in the Mystic core, both cores show a correlation between society's time-varying industrial and energy system development phases and BC increase, with peak values in both settings between 1960 to 1970.

Historical trends in radiocarbon based source apportionments provide a reconstruction of the pre-industrial to post-industrial soot BC emissions. Both cores show a correlation between industrial periods and low radiocarbon signal of soot-BC, with dominantly fossil fuel signatures between 1960 to 1970. Delta 13C data support shifts from predominantly coal to petroleum use post-1970. Specifically in the Mystic core, there exists a dramatic shift in BC signatures from overwhelmingly biomass burning at the end of the 1800s to majority fossil fuel sources near 1960 to a 50/50 mix in surface sediments. This data is informative of the soot-BC loadings, likely to be regionally differing and thus requiring coverage in different regions.