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Radiocarbon based source apportionment of black carbon in the form of PM10 elemental carbon aerosol particles at the Zeppelin Observatory, Svalbard

Patrik Winiger (1), August Andersson (1), Karl Espen Yttri (2), Peter Tunved (1), and Örjan Gustafsson (1)

(1) The Department of Applied Environmental Science and Analytical Chemistry (ACES) and the Bolin Centre for Climate Research, Stockholm University, Stockholm, Sweden, (2) NILU-Norwegian Institute for Air Research, Kjeller, Norway

Black carbon (BC) aerosol particles are formed from incomplete combustion of fossil fuel and biomass. Transported into the Arctic, they potentially contributes to climate warming. However, there are still large uncertainties related to the climate effects of BC, including aspects of radiative properties, mixing state of the particles, transport, atmospheric lifetime and sources. The current study aims to reduce source uncertainties by applying a top-down (observational) source-diagnostic isotope approach and comparing these to bottom-up (modeling) emission inventories to better constrain the source types and source regions. The use of natural abundance radiocarbon ($\Delta^{14}C$) is a powerful tool to distinguish between fossil (void of ^{14}C) and biomass (contemporary ^{14}C) combustion sources. Due to the well-defined end-members, ^{14}C-measurements (alone) provide high precision (<5%) source constraints. The ^{14}C-based source characterization is performed directly on elemental carbon (EC), a methodically defined form of BC. In addition to the ^{14}C-characterization, additional source information may be obtained from analysis of the stable carbon ($^{13}C/^{12}C$) signature.

The present study is focusing on 12 episodes with a high EC loading (mostly 24h samples) observed in the European Arctic (Zeppelin Observatory, Svalbard) from January to March 2009. These pollution events are typically associated with long-range transport. The results show that on average, biomass burning is the major fraction of EC during these high-loading events, although by a short margin. This finding is contradictory to what is suggested by year-round emission inventory models, suggesting that EC in the Arctic is dominated by fossil fuel emissions. The 12 episodes studied account for 25% of the overall observed time, but account for almost 75% of the collected EC mass. Wildfire and agricultural fire emissions can be excluded almost entirely during the winter season, hence anthropogenic sources using biomass for residential heating are the most likely origin.