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Different characteristics of char and soot in the atmosphere and their ratio as an indicator for source identification in Xi'an, China

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Abstract. Numerous definitions and analytical techniques for elemental (or black) carbon (EC) have been published in the scientific literature, but still no generally accepted interdisciplinary definition exists. EC is not a single chemical compound, but is mainly composed of two parts of carbon contents: combustion residues from pyrolysis and combustion emissions formed via gas-to-particle conversion. Accordingly EC is subdivided into two classes: char and soot. Char is defined as carbonaceous materials obtained by heating organic substances and formed directly from pyrolysis, or as an impure form of graphitic carbon obtained as a residue when carbonaceous material is partially burned or heated with limited access of air. Soot is defined as only those carbon particles that form at high temperature via gas-phase processes. Since the different classes of EC have different chemical and physical properties, their optical light-absorbing properties differ, so that it is essential to differentiate them in the environment. The thermal optical reflectance (TOR) method was used to differentiate between char-EC and soot-EC according to its stepwise thermal evolutional oxidation of different carbon fractions under different temperatures and atmosphere. Char-EC and soot-EC are operationally defined as EC1-OP and EC2+EC3 (EC1, EC2 and EC3 corresponding to carbon fractions evolved at 550, 700 and 800 °C in a 98% He/2% O_2 atmosphere, respectively), respectively. One year of observations of the daily and seasonal variations of carbonaceous particles were conducted in Xi'an, China in 2004 to demonstrate the different characteristics of char and soot in the atmosphere. Total carbon (TC), organic carbon (OC), EC and char-EC showed similar seasonal trends, with high concentrations in winter and low concentrations in summer, while soot-EC revealed relatively small seasonal variations, with maximum concentration (1.85±0.72 μg m^{-3}) in spring and minimum concentration (1.15±0.47 μg m^{-3}) in summer. The strong correlation between EC and char-EC (R^2 = 0.99) and poor correlation between EC and soot-EC (R^2 = 0.31) indicate that previously reported total EC in the literature reflected the distribution characteristics of char only, while overlooking that of soot. However, soot exhibits stronger light-absorbing characteristics than char, and merits greater focus in climate research. The small seasonal variation of soot-EC indicates that soot may be the background fraction in total EC, and is likely to have an

even longer lifetime in the atmosphere than previously estimated for total EC, which suggests that soot may has a greater contribution to global warming. While both char-EC/soot-EC and primary OC/EC ratios vary with emission sources, only OC/EC ratio is affected by SOA. Thus char-EC/soot-EC may be a more effective indicator than OC/EC in source identification of carbonaceous aerosol. Comparison of seasonal variations of OC/EC and char-EC/soot-EC ratios in Xi'an confirms this point. However, wet scavenging by snow and rain was more effective for char than for soot and influenced the char-EC/soot-EC ratio, and this factor should be considered in source identification as well.

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