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A European aerosol phenomenology-5: Climatology of black carbon optical properties at 9 regional background sites across Europe

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A reliable assessment of the optical properties of atmospheric black carbon is of crucial importance for an accurate estimation of radiative forcing. In this study we investigated the spatio-temporal variability of the mass absorption cross-section (MAC) of atmospheric black carbon, defined as light absorption coefficient (sigma(ap)) divided by elemental carbon mass concentration (m(EC)). sigma(ap) and m(EC) have been monitored at supersites of the ACTRIS network for a minimum period of one year. The 9 rural background sites considered in this study cover southern Scandinavia, central Europe and the Mediterranean. sigma(ap) was determined using filter based absorption photometers and m(EC) using a thermal-optical technique. Homogeneity of the data-set was ensured by harmonization of all involved methods and instruments during extensive intercomparison exercises at the European Center for Aerosol Calibration (ECAC). Annual mean values of sigma(ap) at a wavelength of 637 nm vary between 0.66 and 1.3 Mm(-1) in southern Scandinavia, 3.7-11 Mm(-1) in Central Europe and the British Isles, and 2.3-2.8 Mm(-1) in the Mediterranean. Annual mean values of mEC vary between 0.084 and 0.23 mu g m(-3) in southern Scandinavia, 0.28 -1.1 in Central Europe and the British Isles, and 0.22-0.26 in the Mediterranean. Both sigma(ap) and mEC in southern Scandinavia and Central Europe have a distinct seasonality with maxima during the cold season and minima during summer, whereas at the Mediterranean sites an opposite trend was observed. Annual mean MAC values were quite similar across all sites and the seasonal variability was small at most sites. Consequently, a MAC value of 10.0 m(2) g(-1) (geometric standard deviation = 133) at a wavelength of 637 nm can be considered to be representative of the mixed boundary layer at European background sites, where BC is expected to be internally mixed to a large extent. The observed spatial variability is rather small compared to the variability of values in previous literature, indicating that the harmonization efforts resulted in substantially increased precision of the reported MAC. However, absolute uncertainties of the reported MAC values remain as high as +/- 30-70% due to the lack of appropriate reference methods and calibration materials.The mass ratio between elemental carbon and non-light-absorbing matter was used as a proxy for the thickness

of coatings around the BC cores, in order to assess the influence of the mixing state on the MAC of BC. Indeed, the MAC was found to increase with increasing values of the coating thickness proxy. This provides evidence that coatings do increase the MAC of atmospheric BC to some extent, which is commonly referred to as lensing effect. (C) 2016 The Authors. Published by Elsevier Ltd.
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