AEROSOL
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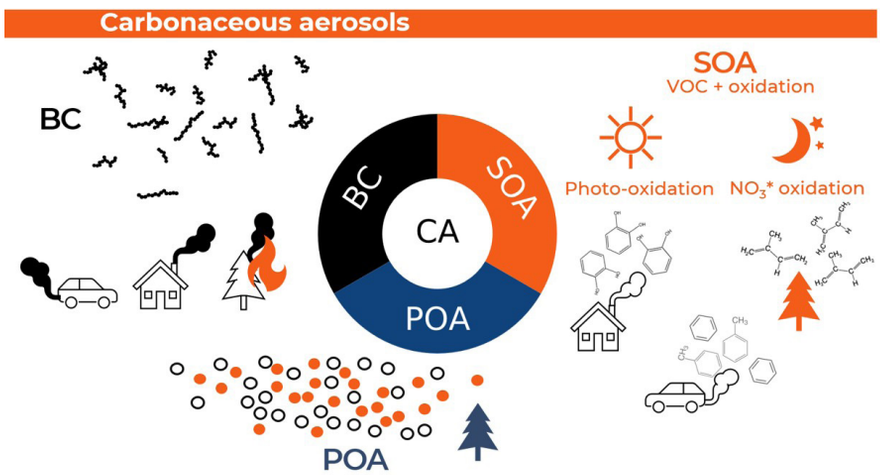
ADVANCED APPORTIONMENT OF CARBONACEOUS AEROSOLS



APPLICATION NOTE

MOTIVATION

Carbonaceous aerosols (CA) are usually the most significant contributor to fine particulate matter (PM2.5). They are known to affect climate change and cause adverse health effects such as penetrating deeply into tissues (cardiovascular or nerve system), producing high potential to inflict oxidative stress, and causing some types of cancer (particularly lung cancer). CA include an organic fraction, organic aerosol (OA), and a refractory, strongly light-absorbing fraction referred to as black carbon (BC). The mass of carbn atoms in CA and OA is called total carbon (TC) and organic carbon (OC), respectively. The BC is exclusively emitted from incomplete combustion (fossil fuel BC_{ff}, biomass burning BC_{bb}), thus having only a primary origin. OA's chemical composition is highly diverse and has many complex molecular structures. OA is directly emitted to the atmosphere in particulate form as primary organic aerosols (POA) by combustion and from biogenic sources, or it can have a secondary origin (SOA). Organic aerosol can be further divided into light-absorbing OA, also known as brown carbon (BrC), and non-light absorbing OA ($OA_{non\text{-}abs}$), both with possible primary and secondary origin (POA_{BrC}, SOA_{BrC}, $POA_{non\text{-}abs}$, $SOA_{non\text{-}abs}$, respectively).

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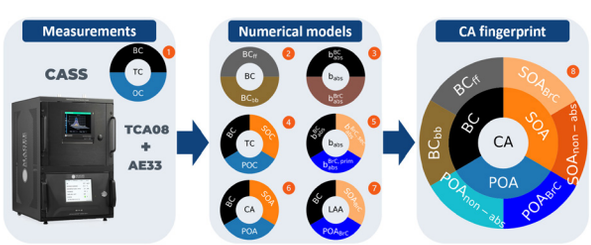
INSTRUMENT & METHOD

The Magee Scientific Carbonaceous Aerosol Speciation System (CASS) is a combined unit consisting of Total Carbon Analyzer TCA08 and the Magee Scientific Aethalometer® model AE33 instruments.

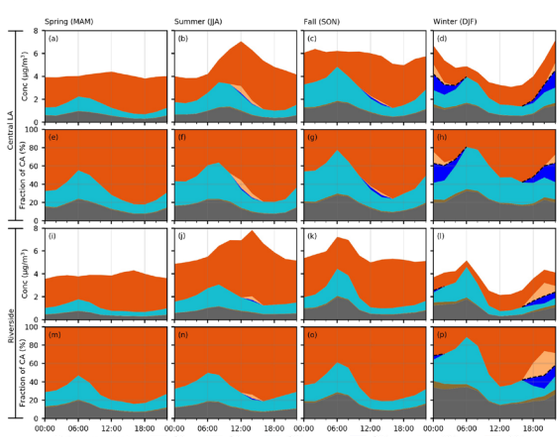
TCA08 instrument has two identical parallel channels. The following principle achieves a continuous operation: while one channel collects its sample, the other analyzes an already collected one. At the end of the collection period, the sample flow is switched from one channel to another. The collected sample is flash-heated for 70 s to approx. 950 – 1000°C to convert all Carbon to CO_2. The CO_2 concentration is then integrated and transformed to concentration (g/cm3) to give the sample's total carbon (TC) content in real time.

Magee Scientific Aethalometer® characterizes Black Carbon (BC/EC) aerosols accumulated on a glass-fiber/ PTFE filter tape. On a defined time base (1 s or 60 s), AE33 reports BC data to TCA08. The OC fraction in CASS is then determined from a simple mathematical formula OC=TC-b*BC, where b is region specific parameter.



APPLICATIONS

The advanced TC/BC(λ) method can be used to study the influence of anthropogenic processes, such as fossil fuel combustion (traffic) or biomass burning (wildfires), on air quality and thus to study the impact of those processes on our daily life, e.g., climate change and public health. Below, we show an example of such an application: diurnal profiles of CA apportioned to BC_{ff}, BC_{bb}, $POA_{non\text{-}abs}$, POA_{BrC}, $SOA_{non\text{-}abs}$, and SOA_{BrC} from two years long campaign in Central LA (a-h) and Riverside (i-p), California, USA. All data are obtained from CASS instrument and afterwards further analyzed by taking into account some specific numerical models (Aethalometer model, Brown Carbon model, EC-BC tracer, BC tracer for BrC, OC-OM model by including MAC values for Black Carbon @ 880 nm and Primary/Secondary Brown Carbon @ 370 nm) to finally obtain the complete CA fingerprint as schematically shown in a chart above.



DISCUSSION

Most SOA in Spring, Summer, and Fall are non-light-absorbing ($SOA_{non\text{-}abs}$). Consequently, we assumed that the biogenic VOC played an important role in the air quality at the considered sites. We found a significant fraction of SOA_{BrC} on winter nights, which can account for up to 20 % of CA (Fig. h,p) and can be associated with precursors from biomass burning. Usually, SOA_{BrC} and POA_{BrC} lose the ability to absorb light with aging and under sunlight-induced photobleaching, which destroys specific chromophores (Chen et al., 2021). Chen et al. (2021) named the process “whitening” of OC, and the process is also evident from these results; both SOA_{BrC} and POA_{BrC} disappeared in winter morning (Fig. d,l). The split between POA_{BrC} and SOA_{BrC} was recognized as the most uncertain point of the results in above Fig. The split in winter nights is marked with a dashed line. A minor but marked SOA_{BrC} contribution to CA was observed at both sites during the summer afternoons, which was not related to biomass burning (Fig. f,n).

Related articles

- Rigler, M., et al.: The new instrument using a TC–BC (total carbon–black carbon) method for the online measurement of carbonaceous aerosols, 13, 4333–4351, https://doi.org/10.5194/amt-13-4333-2020, 2020.
- Drinovec, L. et al. The dual-spot Aethalometer: an improved measurement of aerosol black carbon with real-time loading compensation. Atmospheric Measurement Techniques 8, 1965–1979 (2015) - https://doi.org/10.5194/amt-8-1965-2015
- Ivančič, M. et al. Long-term, high-time-resolution apportionment of primary and secondary carbonaceous aerosols in the Los Angeles Basin using an advanced total carbon–black carbon (TC-BC(λ)) method. Science of Total Environment. Vol. 848, 20 November 2022, 157606(2022) - https://doi.org/10.1016/j.scitotenv.2022.157606

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Keeping an Eye on the Air