Aerosol and Air Quality Research, 11: 539–546, 2011

ISSN: 1680-8584 print / 2071-1409 online
doi: 10.4209/aaqr.2011.05.0055

Post-processing Method to Reduce Noise while Preserving High Time Resolution in Aethalometer Real-time Black Carbon Data

Gayle S.W. Hagler[1]*, Tiffany L.B. Yelverton[1], Ram Vedantham[2], Anthony D.A. Hansen[3], Jay R. Turner[4]

[1] *US EPA, Office of Research and Development, National Risk Management Research Laboratory, Research Triangle Park, NC, USA*
[2] *US EPA, Office of Research and Development, National Exposure Research Laboratory, Research Triangle Park, NC, USA*
[3] *Magee Scientific, Berkeley, CA, USA*
[4] *Department of Energy, Environmental and Chemical Engineering, Washington University, St. Louis, MO, USA*

ABSTRACT

Real-time aerosol black carbon (BC) data, presented at time resolutions on the order of seconds to minutes, is desirable in field and source characterization studies measuring rapidly varying concentrations of BC. The Optimized Noise-reduction Averaging (ONA) algorithm has been developed to post-process data from the Aethalometer, one of the widely used real-time BC instruments. The ONA program conducts adaptive time-averaging of the BC data, with the incremental light attenuation (ΔATN) through the instrument's internal filter determining the time window of averaging. Analysis of instrument noise and the algorithm performance was conducted using Aethalometer 1-second data from a soot generation experiment, where input BC concentrations were maintained constant and an optimal ΔATN_{min} value was defined. The ONA procedure was applied to four additional data sets (1 s to 5 min data), including cookstove emissions tests, mobile monitoring, continuous near-road measurements, and indoor air sampling. For these data, the algorithm reduces the occurrence of negative values to virtually zero while preserving the significant dynamic trends in the time series.

Keywords: Smoothing; Aerosol; Carbonaceous; Soot; Aethalometer.

INTRODUCTION

Atmospheric black carbon (BC) is an important indicator of combustion emissions in ambient or indoor environments, may have direct impacts on health (e.g., Driscoll *et al*., 1996; Stoeger *et al*., 2006), and has been highlighted as a significant forcing agent for climate change (e.g., Ramanathan and Carmichael, 2008). Field studies around the world quantify atmospheric black carbon through two general approaches – off-line measurements where a sample is collected onto a filter and then measured in a laboratory setting; and online measurements where BC is continuously measured and reported on a time base of seconds to minutes. Online measurements are critical to research studies characterizing short-term variability in BC, such as measuring source emissions that change rapidly, quantifying outdoor air pollution levels while moving on a mobile platform or lofted in a balloon, comparing time-varying indoor air pollution levels with health indicators, or observing dynamic trends in ambient air quality.

Among the current approaches available to measure BC in an online fashion, filter-based optical techniques such as the Aethalometer™ (Magee Scientific), multi-angle absorption photometer (MAAP, Thermo Scientific), and the particle soot absorption photometer (PSAP, Radiance Research) are in widespread use due to their ease of operation, relatively low cost, and established development history. Recent innovations on the Aethalometer have extended the range of BC measurement applications, with new models (AE42, AE51) providing greater portability by reducing the instrument size and operating from internal battery power. Portable BC instruments have been carried by volunteers or placed in homes to conduct personal exposure monitoring, lofted in a balloon to perform vertical-profile sampling (Babu *et al.*, 2011), and used on-board mobile sampling vehicles to measure in-cabin or outdoor air quality (Beckerman *et al*., 2008; Kozawa *et al*., 2009; Wang *et al*., 2009).

One challenge facing BC measurements via filter-based techniques is measurement sensitivity. Filter-based optical

* Corresponding author. Tel.: 1-919-541-2827;
Fax: 919-541-0359
E-mail address: hagler.gayle@epa.gov