Investigating the aethalometer model to estimate black carbon and airborne particles from wood burning

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Introduction

Although air pollution from wood burning is a recognised problem in the Scandinavian and Alpine areas there is a risk that the European Union commitment to obtain 20% energy from renewable sources is leading to a return to urban wood combustion. New evidence of urban wood burning is emerging from studies in London, Paris, Berlin (Fuller et al 2013) and with member states of the European Union committed to obtain 20% of their energy requirements from renewable sources by 2020, increased wood burning is inevitable.

Quantification of PM from wood burning through the filter based measurement of tracers such as anhydrous sugars produced from the charring of cellulose (mainly levoglucosan) and fine potassium is both expensive and has poor time resolution. The aethalometer (Magee Scientific) offers an alternative method to assess PM_{10} from wood smoke based on its different optical absorption characteristics compared with black carbon; notably increased absorption in the UV wavelength compared to IR which can be used to apportion black carbon (BC) between fossil fuel and wood burning and to provide a tracer for PM from wood burning (Sandradewi et al., 2008).

The aethalometer method for tracing of wood burning PM is subject the assumed values of the angstrom coefficients for fossil fuels (αff) and wood burning (αwb). However, the sensitivity of the wood burning tracer, B_{abs} wb (370), to assumptions of αff and αwb have not been fully explored.

Measurement methods

Aethalometer (2λ) and Sunset EC/OC measurements were undertaken in London, UK, from 2008 to 2011 along with two short term (~40 day) levoglucosan measurement campaigns during winter 2009 and 2010.

Results and discussion

By varying αff and αwb by 10% from the commonly used values of αff =1.0 and αwb = 2.0 it was found that mean B_{abs} wb (370) in London was more sensitive to changes in αff (+20% at αff =0.9 and -26% at αff = 1.1) than it was to changes in αwb (-10% at αwb = 2.2 and +16% at αwb = 2.2).

Having two independent methods to measure wood burning PM, provided further opportunities to conduct sensitivity testing and to assess the validity of the athelometer method. Using αff =1.0 and αwb = 2.0, correlations (r^2) between levoglucosan and B_{abs} (370) wb were good (0.79) and this did not vary when αwb was varied between 1.8 and 2.2. The magnitude of the levoglucosan and B_{abs} (370) wb cannot be usefully used test variations in αff and αwb since both require the applications of further factors before an estimate of PM mass concentration can be obtained, however, zero concentrations of both tracers should occur at the same time. Although zero measurements were not present in the dataset, the regression intercept of levoglucosan on Babs (370) wb should be zero if the methods are consistent. Figure 1 shows how the reduced major axis regression intercept varied as αff was varied between 0.2 and 1.3. It was found that an intercept of zero was only possible at a αff value of 0.96, consistent with the literature estimates. At this value the intercept became insensitive to variations in αwb. Looking at this test in another way, the derivation of a value of αff; a physical property of ambient aerosol of 0.96, consistent with literature estimates contributes to the validity of the athealometer method to trace wood burning PM. Figure 1 also shows the effect of a varying αff on the magnitude of Babs (370) wb, with αwb between 1.8 and 2.2. It can be seen that the sensitivity of B_{abs} (370) wb to changes in αwb were fairly constant for values αff < 1 but it became insensitive to changes in αwb as the athelometer model broke down and produced large negative intercepts with values of αff above 1.2.

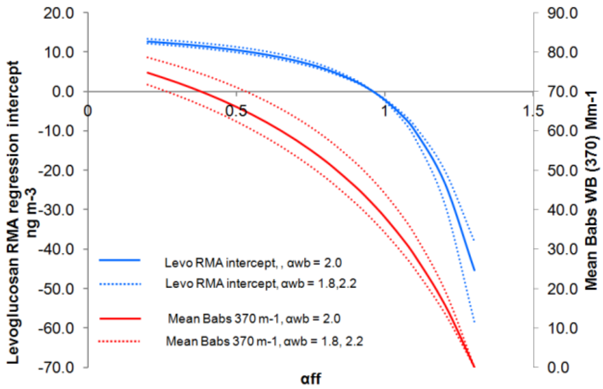

Figure 1 Regression intercept as a function αff (black line). Grey line shows B_{abs} (370) wb, with αwb between 1.8 and 2.2.

References

Fuller et al 2013. Atmos Env 68 (2013) 295–296
Sandradewi et al., 2008. Environ. Sci. Technol. 2008, 42, 3316–3323.

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