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Seasonal Variations of Light-Absorbing properties in Atmospheric Aerosols in Southern Sweden

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Introduction

During recent years, the scientific interest has shifted from regarding light absorbing carbon (LAC) in the atmospheric aerosol as merely a pollutant to an important driver of global warming. LAC can affect the climate by absorbing light and emitting heat, thus LAC has a warming effect on the climate. The radiative forcing of soot, which is one of the key components in LAC, has recently been estimated to be as large as +1.1 W/m^2 [1]. This will make soot together with CH_4 the largest climate forcer next to CO_2, however the uncertainty in this estimate is still high.

To decrease this uncertainty, accurate and correct data on the sources and their emissions of aerosols need to be delivered. The aethalometer is a high time resolution, real-time instrument for measurement of aerosol absorption. It measures the light attenuation through a particle-loaded filter at seven wavelengths. By means of calibration, attenuation is converted to absorption which is the climate-relevant quantity. Wood smoke aerosols, or brown carbon (BrC), are thought to absorb light more efficiently in the lower wavelengths (370-470 nm) than black carbon (BC) [2]. Due to this spectral dependence it is possible to deduce which source that has the highest influence on temporal variations in aerosol absorption.

Methods

The optical absorption of aerosol particles collected on filters was measured with a 7-wavelength (370, 470, 520, 590, 660, 880 and 950 nm) aethalometer at the Vavihill background field station in southern Sweden (56°01'N, 13°09'E, 172 m.a.s.l.). The measurement took place June-December 2012 and February-August 2013. The wavelength dependent aerosol absorption coefficient, $\sigma_{abs}(\lambda)$, was used to derive the aerosol ångström exponent, *AAE*, with following equation:

$$\sigma_{abs}(\lambda) = K \cdot \lambda^{-AAE}$$

Where K is a fitted constant and λ is the wavelength. By calculating monthly means of $\sigma_{abs}(\lambda)$, monthly means of *AAE* taken over the entire wavelength range (370-950 nm) could be estimated. Since there is a spectral dependence of aerosol absorption, *AAE* was plotted as a function of temperature. A higher influence from biomass combustion during the cold seasons would yield more BrC relative to BC, which would then result in a higher *AAE* value. A relationship might be an indicator of biomass burning since this is thought to increase during the cold winter months and thus *AAE*. The temperature was measured at Helsingborg weather station (56°03'N, 12°77'E), situated 25 km west from Vavihill field station

Results and Discussion

The results of the aerosols absorption measurements are shown in figure 1 and 2. The aerosol absorption coefficient, σ_{abs}, was highest in the lower wavelengths (370-470 nm) and during October 2012 to April 2013 (figure 1A and 1B). The absorption ångström exponent *AAE* was found to vary between 1 and 1.4, with the highest values October 2012 to April 2013 (figure 2A). There is also a clear negative relationship (r^2=0.84) between *AAE* and temperature. Thus, there is a seasonal variation in aerosol absorption with high values of *AAE* during the winter months. Since the absorption is strongest in the lower wavelengths (370-470 nm) (figure 1A and 1B), this variation is probably due to residential wood combustion for heating houses.

With comparison of data from other measurement techniques such as levoglucosan and SP-AMS analysis, it is possible to confirm these seasonal variations and estimate the contribution of residential wood combustion to the carbonaceous aerosol.

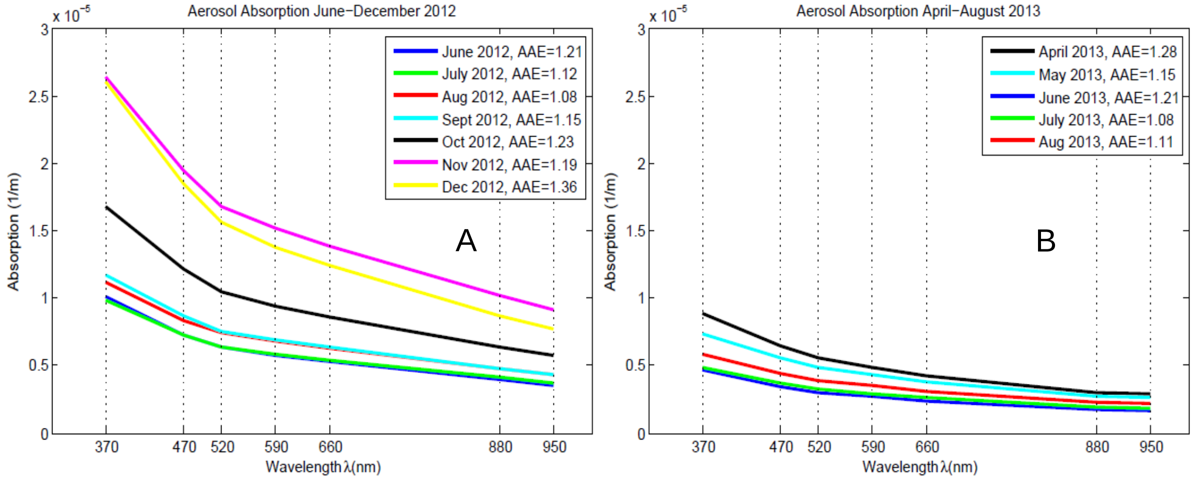

Figure 1. Monthly mean aerosol absorption measured with seven wavelength aethalometer at Vavihill field station, June-December 2012 (**A**) and April to August 2013 (**B**). The mean monthly absorption ångström exponents (AAE) are stated in the legend for each graph.

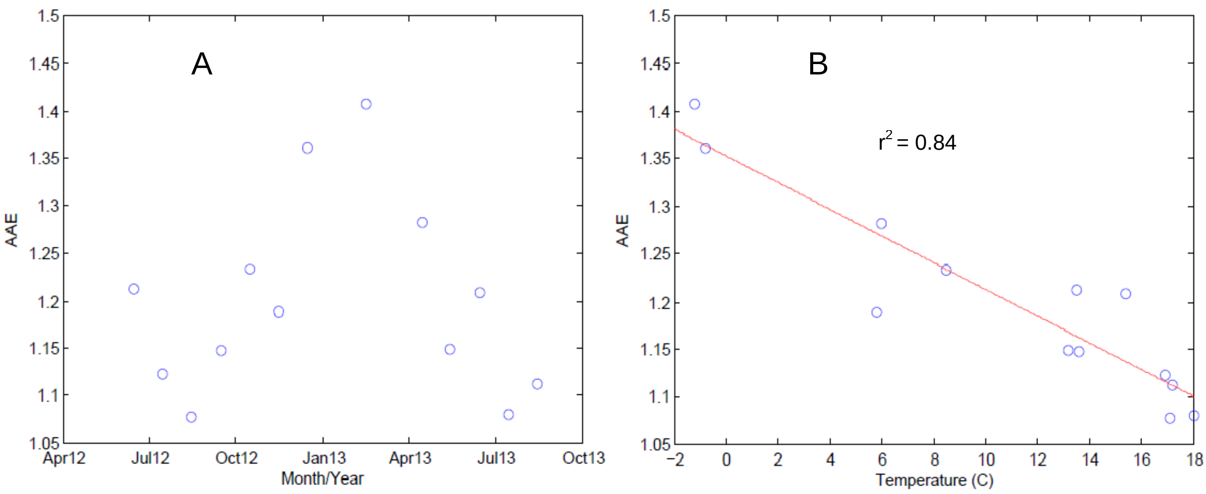

Figure 2. Monthly mean absorption angstrom exponents (AAE) at Vavihill field station as a function of time (June 2012 - August 2013) (**A**). Monthly mean absorption angstrom exponents (AAE) at Vavihill field station as a function of monthly mean temperature at Helsingborg weather station during June 2012 - August 2013 (**B**).

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