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Aerosol volatility in a boreal forest environment

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Climate and health effects of atmospheric aerosols are determined by their properties such as their chemical composition. Aerosol chemical composition can be studied indirectly by measuring volatility of aerosol particles. The volatility of submicron aerosol particles (20-500 nm) was studied in a boreal forest site at SMEAR II (Station for Measuring Ecosystem-Atmosphere Relations II) station (Vesala et al., 1998) in Hyytiälä, Finland, during 01/2008-05/2010. The instrument used for the measurements was VDMPS (Volatility Differential Mobility Particle Sizer), which consists of two separate instruments: DMPS (Differential Mobility Particle Sizer, Aalto et al., 2001) and TD (Thermodenuder, Wehner et al., 2002).

Aerosol evaporation was examined by heating the aerosol and comparing the total aerosol mass before and after heating. In the VDMPS system ambient aerosol sample was heated up to temperatures ranging from 80 ºC to 280 ºC. The higher the heating temperature was the more aerosol material was evaporated. There was a non-volatile residual present in aerosol particles when heated up to 280 ºC. This residual explained (20±8)% of the total aerosol mass. Aerosol non-volatile mass fraction was highest during winter and smallest during summer months.

The role of black carbon in the observed non-volatile residual was determined. Black carbon explained 40 to 90% of the non-volatile mass. Especially during colder seasons noticeable amount of non-volatile material, something else than black carbon, was observed. According to Kalberer et al. (2004) some atmospheric organic species can form polymers that have high evaporation temperatures. Also low-volatile organic salts may contribute to the non-volatile aerosol (Smith et al., 2010).

Aerosol mass composition measured directly with AMS (Aerosol Mass Spectrometer, Jayne et al., 2000) was analyzed in order to examine the properties of the non-volatile material (other than black carbon). The AMS measurements were performed during spring and autumn 2008. Results from the aerosol mass spectrometry indicate that the non-volatile residual consists of nitrate and organic compounds, especially during autumn. These compounds may be low-volatile organic nitrates or salts. During winter and spring the non-volatile core (black carbon removed) correlated markedly with carbon monoxide, which is a tracer of anthropogenic emissions. Due to this, the non-volatile residual may also contain other pollutants in addition to black carbon. Thus, it seems that the amount of different compounds in submicron aerosol particles varies with season and as a result the chemical composition of the non-volatile residual changes within a year.

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