Using a Single Particle Soot Photometer to detect and distinguish different absorbing aerosol types

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The Single Particle Soot Photometer (SP2) was originally designed to measure (refractory) black carbon, but also absorbing materials different from black carbon can be detected. This presentation shows results from experiments with volcanic ash and hematite, performed during two laboratory studies, and introduces a method to distinguish these materials from black carbon.

The SOOT11 campaign at the KIT AIDA (Aerosol Interaction and Dynamics in the Atmosphere) chamber in November and December 2010 was dedicated to compare the performance and efficiency of six different SP2s (Laborde *et al*. 2012). During one experiment of the SOOT11 campaign, a ground sample of ash from the Eyjafjallajökull volcano was brought into the AIDA chamber to test the SP2's sensitivity to absorbing materials different from black carbon. The volcanic ash aerosol remained in the AIDA chamber for several hours and was mixed externally with black carbon later in the experiment. Experiments with pure hematite and an external mixture of hematite and black carbon were performed as part of the Boulder light absorption intercomparison study (BLAC09) in January and February 2009.

The SP2 uses laser-induced incandescence to measure the mass of individual absorbing particles which are heated in a continuous laser beam with Gaussian intensity distribution such that they emit thermal radiation and evaporate. This radiation is detected at two different visible wavelength bands. The ratio of the signals from the two incandescence channels, the color ratio, provides a relative measurement of the incandescence temperature of the particle (Moteki & Kondo 2010). While a particle passes the laser beam, also the scattered laser light is recorded. Initially, this scattering signal allows to derive the optical size of the whole particle before evaporation started. In contrast, the scattering signal at the point of maximum incandescence corresponds to the optical size of the incandescing particle core.

Both volcanic ash and hematite were found to be detectable in the SP2 incandescence channels with low efficiency only, as they absorb light less efficiently than black carbon. About 5-10% of all measured particles were detected in the incandescence channels, with the percentage rising with size.

Comparisons between the different materials show that the color ratio is larger for black carbon than for both volcanic ash and hematite, because the incandescence temperatures of those materials are lower. For both mixtures, the color ratio shows two peaks: one at the level of black carbon, and one at a lower level corresponding to the less absorbing material. This method is difficult to apply for single particles, because the color ratio may be noisy, especially for small particles.

A more precise distinction between the materials can be made by using the differences in both optical and physical properties. Volcanic ash and hematite particles with similar incandescence signals will have scattering signals different to those of black carbon particles at the point of incandescence, as they have different incandescence temperatures and refractive indices. Therefore, the ratio between the signals in the scattering and incandescence channels at the point of incandescence shows a strong dependence on material. Figure 1 shows this ratio for the volcanic ash experiment of the SOOT11 campaign. The data points separate into two clusters: the lower one represents the black carbon particles, while volcanic ash particles have higher values with a distinct gap between the two materials. This makes it possible to distinguish materials on a particle-by-particle basis.

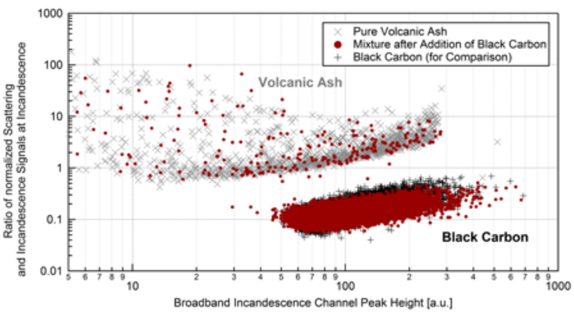

Figure 1: Signal ratio at incandescence for volcanic ash before and after the addition of black carbon (SOOT11 experiment). Pure black carbon data from another experiment are added for comparison

Laborde, M, *et al*. (2012) Single Particle Soot Photometer intercomparison at the AIDA chamber, manuscript in preparation.
Moteki, N & Kondo, Y (2010) *Aerosol Science & Technology*, **44** (8), 663–675.