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A Comparative Study of the Properties of Individual Black Carbon Particles Measured in Urban, Marine, and Stratospheric Environments

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Objectives and Motivation

Droplet Measurement Technologies has developed an instrument that measures the mass concentration of individual black carbon (BC) particles.This instrument has been deployed on three different field campaigns to measure the characteristics of BC in three widely disparate environments: 1) Mexico City (large urban area), 2) off the coast of Monterrey, California (marine) and 3) over the Arctic (stratosphere). These measurements have been analyzed with two objectives in mind:

1) To compare the properties of BC particles found in urban, marine and stratospheric environments;

2) To evaluate specific features of the BC particles that may uniquely identify their possible sources and age.

The motivation for this study is to further our understanding of how BC particles impact the thermodynamic structure of the atmosphere, modify the evolution of clouds and contribute to changes in regional and global climate. Very few measurements have been made of the properties of these particles with adequate temporal and spatial resolution and very little is known about evolution and transport of these particles after they are produced by aircraft, urban emissions or biomass burning. The development of the SP-2, and recent measurements in environments with distinctly different meteorological and chemical characteristics provide the opportunity to study BC properties and, by evaluating similarities and differences in these properties, to advance our understanding of how such particles evolve and about the processes that participate in this evolution.

Instrumentation

The Single Scattering Soot Photometer (SP2) measures light scattering from individual particles at the wavelength of incident light (1064 nm) and emitted light from particles that incandesce when heated during light absorption. The emitted light is measured in two spectra bands, 350 – 800 nm and 630 – 800 nm.

Particles that absorb light will first be detected by their scattering signal, followed by light emission during incandescence. The data system records the digitized pulses from the four detectors. The information relevant to the physical and chemical characteristics of the light absorbing particles (LAP) are:

1) Pulse amplitudes of scattering (BC diameter) and incandescence (BC mass)

2) Pulse full width half maximum (BC mass and fraction of total particle mass)

3) Distance between scattering peak and incandescence peak (BC mass and fraction of total particle mass)

Results

The measurements were made between 8 and 12 Km in the Arctic stratosphere during the SAGE III Ozone Loss Validation Experiment (SOLVE II), January 19-February 6, 2003, with the SP-2 installed on the NASA DC-8. The urban measurements were made in Mexico City (19.5˚ N, 99˚ W**),** from April 25 10 to May 1, 2003, as part of ongoing particle physics studies by the Micro and Mesoscale Interactions research group (directed by G. Raga) at the Center for Atmospheric Sciences, UNAM. The measurements off the coast of Monterrey (30˚-34˚ N, 122˚ – 123˚ W**)** were made during the month of July, 2003, as part of the Coastal Stratocumulus Imposed Perturbation Experiment (CSTRIPE). The SP-2 was mounted in the CIRPAS Twin Otter.

A comparison of the relative number of particles as a function of size of BC and the non-BC particles show distinct differences in the particle distributions, i.e.

1) In all three regions cases the smallest particles (< 0.3 μm) are dominated by BC.

2) The urban environment has the highest fraction of BC > 0.3 μm.

3) Stratospheric BC rapidly decreases in concentration with size but the stratosphere had the highest fraction of BC with respect to the total number of particles.

4) The marine environment had the lowest fraction of BC and the majority of the BC was in particles < 0.5 μm.

The frequency distributions as a function of BC mass show that the urban and stratospheric environments have similar mass distributions, with maximum frequency at the smallest detectable mass of 0.01 pg. The mass distribution for the marine boundary layer has a maximum at 0.02 pg and a secondary maximum at 0.04 pg. The secondary peak could be formed by secondary growth mechanisms, such as coagulation or cloud processing. The majority of particles contain BC mixed with non-light absorbing material. The comparison of BC mass fractions from the three different environments, with respect to how frequently the different fractions occur, show marked differences:

1) The BC in the stratosphere has a uniform distribution of frequencies over all mass fractions. This suggests that it is equally likely to find a particle with no BC material as to find particles with only a small fraction. This suggests a well-mixed, well- aged particle distribution with little additional mass that is transferred to the surfaces of particles by other processes in the stratosphere.

2) The majority of particles in the marine boundary layer contain approximately 20% BC mass; however, there is a sub- group of the population that are only BC, suggesting that cloud processing might have removed the soluble material, leaving only the insoluble, BC.

3) The urban particles are distributed bimodally by BC mass fraction. Most of the particles contain less than 5% by mass of BC; however, there remains another group of particles that contain between 10% and 20% of light absorbing material, possibly a result of coagulation. The much lower mass fractions might be a result of the higher concentrations of organic material that form on soot particles during combustion.

References

Baumgardner, D., G. Kok, G. Raga, 2004: Warming of the Arctic Lower Stratosphere by Light Absorbing Particles, *GRL*, 31, L06117, doi:10.1029/2003GL018883