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Laboratory Studies of the Optical Properties of Warming Aerosols with the SP2 and Photoacoustic Spectrometer: Soot and Hematite

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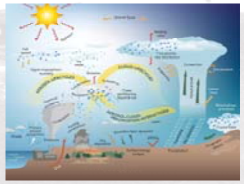
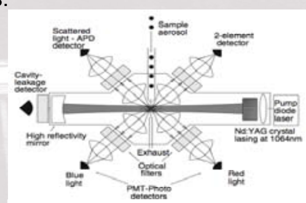
Introduction



- Most aerosols cool the atmosphere by scattering radiation. Absorbing aerosols, such as **black carbon (BC)** from combustion and **hematite** in dust, absorb radiation, resulting in a **warming of the atmosphere**.
- It is currently thought that BC is the second most important factor in global warming behind carbon dioxide, while dust is one of the major components of ambient aerosols globally.

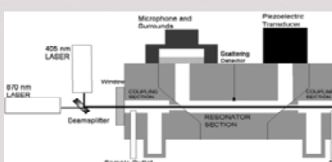
Instrumentation

- **Direct online measurements** of BC and hematite, an absorbing dust aerosol, can be made with the **single-particle soot photometer (SP2)**, which measures the size and mass of the particles by incandescence and scattering on an individual particle basis.
- **SP2: Direct, online measurement of Black Carbon (BC)**
  - Highly sensitive: LOD ≤ 10 ng/m^3 (< 0.4/cm^3)
  - Number and optical size of non-BC particles (from scattering)
    - Approx. 125-400 nm d
  - BC size (derived from mass)
    - Approx. 10-700 nm d



Schwarz, J.P., et al. JGR-A, 111, D16207, 2006.

- Measurements from the SP2 are combined with absorption measurements from the **three-wavelength photoacoustic soot spectrometer (PASS-3)** at 405, 532, and 781 nm and the **ultraviolet photoacoustic soot spectrometer (PASS-UV)** at 375 nm in order to determine **wavelength-dependent mass absorption cross sections (MACs)**.

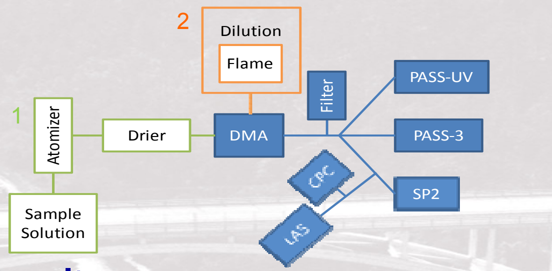


Tian, G., et al. AS&T, 43, 1084-1090, 2009.

- **PASS: Direct, online measurement of Black Carbon (BC) mass and number**
  - Aerosol absorption coefficient (B_{abs})
  - Aerosol Scattering Coefficient (B_{sca})
  - Single Scatter Albedo (SSA)

Experimental Design

- Methods of Aerosol Generation
  1: particles are atomized from aqueous solution, dried with a diffusion drier, and size-selected with a diffusion mobility analyzer (DMA)
  2: flame-generated particles are diluted with particle free air, then sent through the DMA
- Measurements
  - SP2 for incandescent mass
  - PASS-3 and PASS-UV for absorption
  - Laser Aerosol Spectrometer (LAS) and Condensation Particle Counter (CPC) for size and number distributions

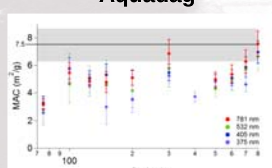


Results

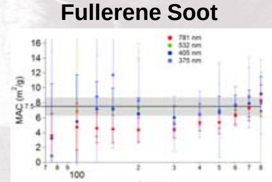
- MAC's from size-selected absorbing aerosols measured in the laboratory
- Particles sampled from 50 – 800 nm d_m
- Aquadag and fullerene soot are used to approximate BC, and are similar, but have lower MAC's than non-denuded nascent soot BC from a kerosene flame

BC (Soot) Surrogates

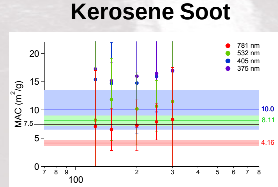
Aquadag



Fullerene Soot

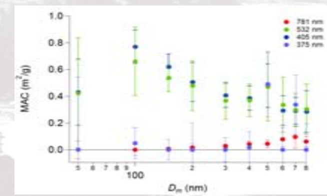


Kerosene Soot



Absorbing Dust Standard

Hematite (Fe_2O_3)



Conclusions

- Comparison with Bond and Bergstrom's suggested MAC_{550nm} of 7.5 ± 1.2 for soot and Cross's average value of 10.0 ± 3.5 at MAC_{405nm}, 8.1 ± 0.9 for denuded soot at MAC_{532nm}, and 4.16 ± 0.5 at MAC_{781n}
- Hematite does not absorb in the red or UV
- Hematite's MAC is an order of magnitude less than soot at 405 nm and 532 nm

Future Work

- Uncertainty analysis of MAC's
- Calculated optical properties using known complex refractive indexes
- Laboratory studies with other soot surrogates, denuded nascent soot, absorbing dust samples, and coated aerosols
- Comparison of lab results with ambient data
- BEACHON-RoMBAS (7-8/2011) investigating biological aerosols in a pine forest
- GVAX (1-3/2012) studying absorbing aerosols in NE India, where some of the highest AOD's have been observed from satellite data

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