Black Carbon: Measurement Issues

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CCAC Marine Black Carbon Emissions Workshop: Identifying Research Gaps
9-10 Sep 2014  Ottawa, ON, Canada
What Needs to be Measured?

• health and environmental researchers and policymakers are asking for more specificity on PM
  – mass and number
  – size and size distribution
  – composition (black carbon, organic carbon, sulphates, nitrates)
  – surface area and surface reactivity
  – optical properties (absorption and scattering)

• BC provides specificity on composition
  – what should be measured for BC?
    • mass
    • number
    • absorption
    • other measurands (size distribution, surface coatings, etc.)?
Measurement Issues (I)

Traceability

• many instruments offer no opportunity for traceability
• filter-based mass can be traceable
  – issues with sensitivity (mass of particulate vs. mass of filter)
  – issues with filter artifacts
    • gaseous adsorption
    • fibre loss
    • less than 100% removal efficiency
  – issues with size cutoff
    • impactors and cyclones do not cut sharply at threshold (i.e. PM$_{2.5}$)
• number concentration can be made traceable
  – ISO/FDIS 27891 - Aerosol particle number concentration -- Calibration of condensation particle counters
Measurement Issues (II)

Reliability and Repeatability

- difficult to establish

Uncertainty

- large uncertainties (can be order of magnitude in number, factor of 2 in mass)

Reference Materials

- airborne particulate RMs don’t exist

Representativeness

- all ex-situ methods suffer from sampling issues
  - how representative is the sample at the measurement location of the airborne particulates?
    - losses – diffusion, thermophoretic, impaction,…
    - agglomeration
    - evaporation/condensation
Measurement Issues (III)

Measuring properties with different methods

• most instruments are proprietary
  – each manufacturer implements a different measurement principle
• difficult to intercompare results obtained with different instruments
• example
  – black carbon mass
    • directly measured, or inferred from optical absorption, extinction, or emission measurements

Calibration

• is the instrument calibrated with a standard method?
• what is the uncertainty?
Measurement Issues (IV)

Measuring specific properties with a myriad of interferences

• selectivity
  – how does one measure properties of BC when many other PM components are present?
• sensitivity
  – atmospheric concentrations are often very low (<1 µg/m³)
• gas composition
  – can be highly variable, especially in engine exhausts
  – can influence measurement
• morphology
  – spherical particles vs. fractal aggregates
• single particle vs. ensemble measurements
• variations over time, elevation, temperature, humidity, sunlight, etc.
Examples of Instruments used to Measure BC: Mass (top row) and Morphology/Size/Number (lower row)

- Laser Induced Incandescence
- Thermal Optical EC/OC Analyzer
- Gravimetric
- Centrifugal Particle Mass Analyzer
- HR-TEM
- Electrostatic Precipitator
- Fast Particle Mobility Size Spectrometer
- Scanning Mobility Particle Sizer
- Condensation Particle Counter
Thank you

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Definition for Black Carbon

“Black Carbon is a distinct type of carbonaceous material that is formed primarily in flames, is directly emitted to the atmosphere, and has a unique combination of physical properties”

• strongly absorbs visible light
• is refractory with a vaporization temperature near 4000 K
• exists as an aggregate of small spheres
• is insoluble in water and common organic solvents