Recommendations for the Interpretation of "Black Carbon" Measurements

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What are the Issues?
Black carbon (BC) has important effects on climate and health
- Recently identified as the second most important climate forcing agent, behind carbon dioxide.
- Small enough to penetrate deep into the human respiratory tract.
- Associated with asthma and other respiratory problems, heart attacks and lung cancer.

BC is poorly defined in the scientific literature
- Carbonaceous matter does not appear in atmospheric aerosols as a pure substance.
- Measurements may refer to the same quantity with different names.
- Measurements of different quantities may be referred to with the same name.

BC measurements depend on the method used
- Current methods respond to different properties of BC.
- Correlations between methods are frequently high, but relationships vary among sites, seasons and aerosol types.

Properties defining Black Carbon and their consequences for atmospheric impacts and lifetime

<table>
<thead>
<tr>
<th>Property</th>
<th>Characteristics</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microstructure</td>
<td>Graphite-like structure containing a high fraction of sp²-bonded carbon atoms</td>
<td>Low chemical reactivity in the atmosphere; slow removal by chemical processes; strong optical absorption</td>
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<tr>
<td>Morphology</td>
<td>Aggregate consisting of small carbon spheres of 10 - 50 nm in diameter</td>
<td>High specific surface area; high capacity for sorption of other species</td>
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<td>Thermal stability</td>
<td>Refractory material with a volatilization temperature near 400K; gasification is possible only by oxidation at T &gt; 340°C</td>
<td>High stability in the atmosphere; longer atmospheric lifetime</td>
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<td>Solubility</td>
<td>Insoluble in organic solvents including methanol and acetone, in water and in the other components of atmospheric aerosol</td>
<td>Slow removal by clouds and precipitation, unless coated with water-soluble compounds; long atmospheric lifetime</td>
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<td>Light absorption</td>
<td>Uniformly absorbing in the VIS; characterized by a significant, non-zero and wavelength-independent imaginary part of the refractive index near UV and NIR spectral regions</td>
<td>Reduction of the albedo of clouds, snow, and ice; atmospheric heating; surface cooling; all of which lead to effects on climate and health</td>
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“Black Carbon” Measurement Methods
- Evolved Carbon
  - CO₂ evolved from thermal or thermo-optical methods; applied analytical protocols, e.g., IMPROVE / EUSAAR
  - BC properties: chemical composition, thermal stability
- Light Absorption
  - Filter-based: Aethalometer, PSAP, MAAP, COSMOS
  - A-alt: photo-acoustic, extinction minus scattering
  - BC properties: light absorption
- Laser Incandescence
  - Laser heating of particles, e.g., SP2, LI, SP-AMS
  - BC properties: refractory, chemical composition
- Aerosol Mass Spectrometry
  - Vaporization and detection of carbon ion clusters in mass spectra: ATOMS, SP-AMS
  - BC properties: chemical composition
- Ramän Spectrometry
  - Detection of graphite-like ordered and disordered carbon
  - BC properties: microstructure
- Electron microscopy
  - Detection of particle microstructure and morphology, e.g., TEM
  - BC properties: morphology

Recommended Terminology
Black carbon (BC) is a useful qualitative description when referring to light-absorbing carbonaceous substances in atmospheric aerosol; for quantitative applications the term requires clarification of the underlying determination.

Evolved black carbon (EBC) should be used instead of BC for data derived from optical absorption methods, together with the factor used to convert light absorption coefficient into mass concentration.

Elemental carbon (EC) should be used instead of BC for data derived from methods that are specific to the carbon content of carbonaceous matter.

Refractory black carbon (RBC) should be used instead of BC for measurements derived from incondensable methods.

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