PRELIMINARY

Presentation by
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Chair, Working Group 1
NACIP Workshop
January 9-11, 2002
Working Group #1: What Improvements are Required in Emission Inventories of Aerosols and Aerosol Precursors?

National Aerosol-Climate Interactions Program (NACIP)

La Jolla, CA

January 9-11, 2002
Important Aerosol and Aerosol Precursors Species in Atmosphere and their Origin

- BC and OC (residential fuel combustion, diesel vehicles, biomass burning)
- SO$_2$ and sulfate aerosol (fossil fuel combustion)
- Non-methane volatile organic compounds (NMVOC) (all kinds, including biogenic)
- NO$_x$, nitrate aerosol, and other nitrogen compounds (vehicles)
- Ammonia (agriculture mainly)
- Mineral dust (wind-blown from arid and semi-arid regions, and industrial/urban activities)
- Sea salt
- DMS
Key Issue is Quantifying BC Emission Estimates
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BC---- “Bery (very) Confusing”
INDOEX measurements show unusually high BC concentrations off the Indian continent (Dickerson et al., 2001)

High BC may be due to biomass burning, vehicle fuel adulteration, small coal combustors or...?
New investigations have forced a re-assessment of BC emission factors (Streets et al., *Atmos. Environ.*, 35, 4281, 2001)
## Summary and Comparison

**Fuel combustion only**

<table>
<thead>
<tr>
<th></th>
<th>Central</th>
<th>Range</th>
<th>Previous</th>
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<tbody>
<tr>
<td></td>
<td>BC</td>
<td>OC</td>
<td>BC</td>
</tr>
<tr>
<td>China</td>
<td>1.14</td>
<td>1.99</td>
<td>0.6-5.3</td>
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<tr>
<td>North America</td>
<td>0.24</td>
<td>0.36</td>
<td>0.2-0.9</td>
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<tr>
<td>South America</td>
<td>0.14</td>
<td>0.22</td>
<td>0.1-1.1</td>
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<td>Europe</td>
<td>0.37</td>
<td>0.49</td>
<td>0.3-1.8</td>
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<td>Former USSR</td>
<td>0.25</td>
<td>0.3</td>
<td>0.1-2</td>
</tr>
<tr>
<td>Africa</td>
<td>0.39</td>
<td>0.88</td>
<td>0.3-1.8</td>
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<tr>
<td>Other Asia</td>
<td>0.58</td>
<td>1.35</td>
<td>0.4-2.4</td>
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<tr>
<td>Pacific</td>
<td>0.16</td>
<td>0.16</td>
<td>0.1-1.1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3.27</strong></td>
<td><strong>5.75</strong></td>
<td><strong>2-16.4</strong></td>
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*Bond & Streets, 2001*
Key Issues in Quantifying BC/OC Emission Estimates

- Clearer definitions of BC/OC and their relationships to measurement techniques and modeling requirements (e.g., absorption) --- *(It is not clear that current measurement capabilities can constrain emission estimates within factor of 2-3)*
- Improvements in fuel-use and activity data (e.g., biomass burning)
- Need to characterize and reduce the uncertainties in emission factors
- Development of more refined emission scenarios linked to sector, fuels, regions, technology
- Estimates of historical emissions
Quantifying Uncertainty is an Important Element

Black Carbon
Fractional Contribution to Variance

- Measured emission factors for coal are highly variable and depend on the coal composition.
- How many “superemitters” are there, and how much do they emit?

- Residential wood
- Residential agr waste
- Res. animal waste
- Residential coal
- Industrial coal
- Diesel vehicles
- Gasoline vehicles
- Other

Suggestions for reducing uncertainties
- Characterize uncertainty in existing data
- Add targeted source measurement programs focused on key variables
Organic Carbon Fractional Contribution to Variance

Wood and agricultural waste burning both emit a lot of OC. There are many more measurements of emission factors for wood.

We need better information on the population and emission factors of two-stroke engines.
Black Carbon Distribution
Black Carbon Uncertainty Distribution
Biomass burning is a large source of aerosols and highly uncertain.
Aerosol and Aerosol Precursors Species in Atmosphere -- Issues

SO$_2$ and sulfate aerosol (fossil fuel combustion)

- Best known
- Key issue is conversion to sulfate
  - When does conversion occur?
  - Where does it occur?
### Aerosol and Aerosol Precursors Species in Atmosphere -- Issues

<table>
<thead>
<tr>
<th>Ammonia emissions (agriculture)</th>
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<tbody>
<tr>
<td>- Rapidly changing</td>
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<td>- Need for gas phase measurements</td>
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<td>- Fertilizer usage in Asia a source of uncertainty</td>
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<table>
<thead>
<tr>
<th>NOx</th>
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<td>- Growing importance due to transport sector growth and sulfur reductions</td>
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<td>- Relatively well known</td>
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Aerosol and Aerosol Precursors Species in Atmosphere -- Issues

**NMVOC (anthropogenic and biogenic)**

- Emissions highly uncertain and speciation of emissions in developing World unmeasured
- Biogenic emissions models untested in many regions
Aerosol and Aerosol Precursors Species in Atmosphere -- Issues

Dust

- Quantitative estimates remain difficult
- Better understanding of size distribution
- Composition inventories in early stages
- Are there regions where “industrial” dust is important?
Unforecasted Dust Storm

TOMS AI April 23, 2001

No Dust Transport Model can simulate this dust

After identified missing dust source just north of Shenyang, post analysised dust concentration retrieve dust onset!
Landuse change at Shenyang within 20 years (1978 - 1998)

Rapidly changed to desert area
Aerosol and Aerosol Precursors Species in Atmosphere -- Issues

Sea Salt
- Quantitative estimates remain difficult
- Better understanding of emissions of small sizes

DMS
- Little predictive ability of source models – no clear way to improve
Bottom-up and top-down approaches are needed
more source testing in developing countries to produce reliable emission factors
Near-source emissions processing – for global models
greater consistency of estimates of primary particulate emissions, particularly BC and OC, by size and chemical composition
special investigations of emissions/modeling/observation inconsistencies (e.g., Asian CO and BC)
Experimental programs like INDOEX, TRACE-P and ACE-Asia promise new insights into pollutant release, transformation, and transport
improve the use of satellite data to develop fine temporal and spatial resolution of biomass burning – explore/develop inverse modeling capabilities
### Research Needs for Regional and Global Emissions -- Summary

- “narrow the gaps” by studying unconventional sources: coal-mine fires, field combustion, waste burning......
- Further development of *transparent* emissions “system” to facilitate sensitivity analysis and emission scenario development
- Develop estimates of historical emissions
- Develop inventories for co-emitted elements/gases - for understanding/scaling emissions (e.g., CH3CN, K, levo-glocusan, ...)
- Design “emission closure” experiments
  
  Activity → mass/composition → absorption