Optical and physical properties of aerosols from biomass combustion

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Radiative effects of aerosols

Kaufman et al., 2002

Climate - radiative forcing

Visibility
Calculating radiative transfer

complex refractive index

1.49 - 0.02i

particle morphology and shape

Optical calculation

OPTICAL PROPERTIES
- scattering cross section
- absorbing cross section
- single scattering albedo
- angstrom exponent

Radiative forcing due to aerosols
Biomass burning aerosol emissions

Fire counts binned into 1x1 degree boxes using the ATSR World Fire Atlas (August 1996 - December 2000)

Jacobson (2001) estimated direct radiative forcing of light-absorbing aerosols equals 1/3 carbon dioxide forcing
Main goal: characterize particulate matter emissions by wildland fires relevant to visibility impairment, PM nonattainment and climate.
USFS Fire Science Laboratory

FLAME CHAMBER
BURNS SETUP

- Cloud microphysics
- Nephelometers
- Size distributions
- f(RH)
- HTDMA
- Extinction cell
- Photoacoustic (absorption)

- Aerosol mass spectrometers

MAIN CHAMBER

- IMROVE sampler
- High volume sampler

~ 40 ft
Fuel selection (chamber burns)

FOREST/PINE FUELS
- PONDEROSA PINE
- LODGEPOLE PINE
- SOUTHERN PINE

BRUSH-TYPE FUELS
- MANZANITA
- SAGE/RABBITBRUSH
- CHAMISE
- JUNIPER
- CEANOTHUS

OTHER FUELS
- PONDEROSA DUFF
- ALASKAN DUFF
- LIGNIN
- ASIAN RICE STRAW

SOUTHEASTERN/TROPICAL FUELS
- PALMETTO
- PUERTO RICO MIXED WOODS
- PUERTO RICO FERN
- WAX MYRTLE
Size distribution examples

Rice straw, Burn E

Ponderosa duff, Burn F
Some initial results from FLAME

Large difference between the properties of flaming versus smoldering fuels
  single scattering albedo
  OC/EC ratio
  ozone interference

FLAMING: HIGHER

SMOLDERING
## Classifying carbon

<table>
<thead>
<tr>
<th>Thermochemical classification</th>
<th>Molecular structure</th>
<th>Optical classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elemental carbon (EC)</td>
<td>Graphene layers</td>
<td>Black carbon (BC)</td>
</tr>
<tr>
<td>Refractory organics</td>
<td>Polycyclic aromatics, Humic-like substances, biopolymers</td>
<td>Colored organics</td>
</tr>
<tr>
<td>Non-refractory organics (OC)</td>
<td>Low-MW hydrocarbons</td>
<td>Colorless organics (OC)</td>
</tr>
</tbody>
</table>

*from Andreae and Gelencser, 2006*
Light absorption versus wavelength

Many previous studies have observed an aerosol absorption wavelength dependency.
Planned filter experiments

Examine spectral absorption characteristics:

- acetone OC extraction
- water-soluble OC extraction
- OC thermal evolution
- primary filter versus backup filter
- high volume filter samples versus IMPROVE samples
- fuel variability
Some areas of investigation

Is there a relationship between UV/visible absorption and fuel type or combustion phase?

How do filter-based wavelength measurements compare to in situ measurements?

Are there any chemical species that are strongly linked to enhanced UV/visible absorption?

How does OC absorption compare to EC assumed absorption?

What impact does OC absorption have on smoke-impacted aerosol radiative forcing?

- ozone production/measurement
- visibility

photoacoustic
AMS GCMS LCMS
AERONET IMPROVE
Summary

Biomass burning aerosols affect climate, but magnitude is highly uncertain

FLAME should provide additional insight on many properties of biomass burning aerosol

LBNL spectral measurements will compliment in situ FLAME observations and hopefully answer some questions about how biomass burning aerosol absorbs light
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