Overview of Aerosol Measurement Activities at Howard University

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Howard University, Washington, DC

Overview of Presentation

• Saharan Dust Measurements
• Beltsville Research Facility
• Urban Air Quality
• Cloud Modification

NCAS Saharan Dust Project
Howard University and UPRM

Objectives

• To obtain comprehensive in-situ measurements of Saharan dust aerosols in the Caribbean with emphasis on Puerto Rico,
• To quantify the microphysical (with focus on morphology, aerodynamic, and optical properties) and chemical evolution of the Saharan dust during transport through the Caribbean,
• To determine how changes in total suspended mass of aerosols impact on the distribution of PM$_{2.5}$, PM$_{10}$, and respirable aerosol in the Caribbean as a result of Saharan dust events, and
• To quantify mass deposition of Saharan dust aerosol in Puerto Rico and to the local Caribbean waters

Input of Saharan Dust in the Eastern Caribbean

Study Site: Castle Bruce Dominica (15°25' N, 61°15' W).
Continuous operation from March 31 to August 1, 2002.
Fungi characterization by morphological features and molecular biology techniques.
PM$_{2.5}$ concentration by gravimetric analysis of sampled filters.
Fungal Characterization
Collaboration with Dr. Carlos Betancourt, Biology Dept., UPRM

Sahara Dust Fungi Identification by Molecular Techniques
Dominica Station
- Aspergillus aculeatus
- A. fumigatus
- A. japonicus
- A. phoenicis
- A. tubingensis
- Cladosporium cladosporoides
- Curvularia braehypora
- Eupenicillium tropicum
- Fusarium equiseti
- Penicillium alberechii
- P. citrinum
- P. phinophilum
- P. verruculosum
- Phanerochaeta sordida

Canary Islands Collaboration
- Two air sampling stations in operation since 1997 at Gran Canaria.
- Mineralogical analysis
- Microbiological analysis:
  - Mycological (UPRM)
  - Bacteriological (PSM)
- Future collaboration between UPRM and ICCM’s serial stations. R/V Ron Brown 2004 cruise and others.

Canary Islands
Filters for Fungal Analysis

<table>
<thead>
<tr>
<th>DATE</th>
<th>CONCENTRATION (µg/m³)</th>
<th>CFU (1/4 filter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 2/03</td>
<td>216.25</td>
<td>264</td>
</tr>
<tr>
<td>March 6-7/03</td>
<td>20.70</td>
<td>118</td>
</tr>
<tr>
<td>May 29/02</td>
<td>31.20</td>
<td>39</td>
</tr>
<tr>
<td>June 12/02</td>
<td>52.52</td>
<td>36</td>
</tr>
</tbody>
</table>
Sahara Dust Samples
Fungal Species
Las Palmas, Gran Canaria Station

- Alternaria alternata
- Alternaria mali
- Ampelomyces sp.
- Aporospora terricola
- Aspergillus fumigatus
- Aspergillus ustus
- Bipolaris spicifera
- Chrysosporium synchroonum
- Corynascus verrucosus
- Curvularia eragrostidis
- Curvularia trifolii
- Emericella rugulosa

Case Study: March 2003 and 2004 Teide, Canary Islands

- Observed the expected trend of a sharp decrease in the aerosol optical thickness with altitude.
- The aerosol optical thickness decreases an order of magnitude between the 1657 and 1930 m locations.
- In the 1930 m altitude we were above the lifting condensation level.
- The third location was chosen because it coincided with the AQUA overpass. This measurement was obtained at an altitude of 1962 m.
- The 2382 m location was taken at the base of the peak.
- The last measurement location at 3566 m was obtained at the peak.

Aerosol Size Distribution

- Evolution of aerosol size distribution as a function of altitude.
- The 0.3 micron size fraction is dominant above the dust plume but contributes less to the total mass in the clean air above the boundary layer.
- The follow-on experiment during March 2004 will allow us to layer the elemental composition and on top of these data.

Work In Progress:
Characterization of Airborne Fungal and Bacterial DNA

- Collaboration: Dr. Jaime Matta (Environmental Toxicology Laboratory, Ponce school of Medicine).
- Genetic material extracted from dust samples will be amplified, purified, sequenced and analyzed by molecular techniques.
Measurement Strategy

- In-situ size-resolved mass and number densities
- Size-resolved filter sampling
- Chemical and microphysical analysis of dust aerosols as a function of size and transport time
- \( \text{PM}_{10}, \text{PM}_{2.5}, \text{Respirable aerosols} \)

Instrumentation

- Quartz Crystal Microbalance
- Cascade Impactor
- Laser Particle Counter

Dust Event of June 24-25, 2002

In-situ data for June 24-25 dust event
Preliminary Results Summary

During the summer 2002 and 2003 dust events we observe:

- The predominant size distributions reaching Puerto Rico under a Saharan dust storm event are in the respirable range.
- The 5 \(\mu\)m size exhibited a 15 fold increase in number density.
- The 0.6 \(\mu\)m size had a 12 fold increase in number density.
- The 2.5 and 1.2 \(\mu\)m size tripled in number density during the dust event.
- Preliminary calculations indicate that the total mass loading for the moderate size event increased by a factor of roughly 2.5.
NCAS Oceanographic Cruise

- Cross-Atlantic Transect from late-Feb through mid-March 2004 (27 days)
- NOAA R/V Ronald H. Brown
- International Collaborations (Spain, Senegal, Cape Verde)
- Significant Interagency Collaborations (NWS, NESDIS, NASA GSFC)
- Joint Atmospheric and Oceanographic Science with focus on Saharan Dust

Science Goals

Long-term Goals

- High temporal and spatial resolution observations of H$_2$O vapor for improving model precip forecast – new Raman Lidar
- Air Quality/Atmospheric Chemistry: In-situ for aerosol characterization, transport of aerosols; dynamics of regional and local O$_3$ chemistry – critical need for evaluating new NOAA air quality forecast system (Just secured agreement for MDE air quality instrumentation at site)

Short-term Goals

- Conduct cloud, radiation and meteorological observations
  - Development and testing of model parameterization – critical need for NOAA models
  - Surface energy budget measurements
  - Modification of cloud optical properties by aerosols
  - Observe atmosphere-surface interaction in heterogeneous environment
- Rainfall measurements
  - Validation of satellite and surface radar rainfall estimates
  - Characterizing error of satellite rainfall estimate for input in NOAA numerical models
- Demonstrate research and training capabilities of site with mini-intensive observation campaign – summer ’04
SWDF = dir * cos(sza) + diff
NSWSF = SWDF - UPSW
NLWSF = DLW - ULW

Air Quality Measurements in Washington, DC

Mass distribution of aerosols by ward:
Fall

Average Particulate Matter Distribution

WARD 1
WARD 4
WARD 5
WARD 7

Ward Distribution of Total PM
Mass distribution of aerosols by ward:

**Summer**

<table>
<thead>
<tr>
<th>Ward</th>
<th>Mass Distribution</th>
<th>Particulate Matter Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARD 1</td>
<td>22%</td>
<td>7%</td>
</tr>
<tr>
<td>WARD 2</td>
<td>32%</td>
<td>9%</td>
</tr>
<tr>
<td>WARD 3</td>
<td>47%</td>
<td>4%</td>
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<tr>
<td>WARD 4</td>
<td>26%</td>
<td>5%</td>
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<tr>
<td>WARD 5</td>
<td>43%</td>
<td>6%</td>
</tr>
<tr>
<td>WARD 6</td>
<td>34%</td>
<td>8%</td>
</tr>
<tr>
<td>WARD 7</td>
<td>36%</td>
<td>7%</td>
</tr>
</tbody>
</table>

**Comparison of Summer and Fall**

Aerosol Number Density Mapping

Comparison of Overall Mass Densities

Aerosol Mass Density Mapping

QCM SUMM OVERALL (mg/m³)

**Overall Total Particulate Matter**

- **SUMMER:** 0.01674 mg/m³
- **FALL:** Range: 0.00254 - 0.03410 mg/m³

**Comparison of Summer and Fall**

- **SUMMER:** Total PM = 0.00183 - 0.00335 mg/m³
- **FALL:** Total PM = 0.00142 - 0.00271 mg/m³

**Comparison of Overall Mass Densities**

- **SUMMER:** Low/High Diff = 0.03410 mg/m³
- **FALL:** Total PM = Range: 0.00142 - 0.00271 mg/m³

**Comparison of Summer and Fall**

- **SUMMER:** Total PM = 0.00183 - 0.00335 mg/m³
- **FALL:** Total PM = 0.00142 - 0.00271 mg/m³
Summary

• Overall, there was a higher concentration of particles during the summer (83.7 µg/m³) than in the fall (49.8 µg/m³). This is about a factor of ~1.7 times more in total particulate matter.

• The Fall IOP generated a higher percentage of 0.15 µm (30%) particles, whereas the summer revealed a greater concentration of 0.30 µm (41%) particles. This is generally consistent with colder temps and lower RH in the late fall season than in the heated summer period.

• Ward 4 consistently ranks among the highest wards in total PM concentration. It is also the highest ranking ward in cancer incidence rates from 1995-1999.

• During the Summer IOP, the rank in mass distribution of 0.30 µm particles for all wards coincides with the ranking of cancer incidence rate in the D.C. area.

• GIS QCM mapping shows a higher concentration of total particulate in Wards 4 and 1 during the Summer IOP and in Wards 5 and 4 during the Fall IOP, respectively.

Objectives

• Simulate modifications of condensation nucleation characteristics using a Differential Mobility Analyzer-Condensation Particle Counter DMA/CNC system

• Investigate the influence of carbonaceous aerosols on cloud condensation nuclei based on changes in:
  - Size distributions
  - Electrical mobility
  - Number distributions
  - Optical extinction

Cloud Modification Studies:

Goals

I. To investigate the relationship between that of carbonaceous aerosols, cloud formation, and regional precipitation.

II. To develop a reliable laboratory technique to generate carbonaceous and aromatic aerosols.

III. To investigate the nucleation properties of aqueous/organic/soot solution which are capable of becoming cloud condensation nuclei.

IV. Investigate optical and radiative properties of cloud aerosols in cloud chamber
Acknowledgements

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