ATOFMS Measurements at Urban and Rural Locations: Comparison of Single Particle Size and Composition

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Overview

- Quantification of ATOFMS measurement
- Application of quantification method to field measurements
Field Campaign

- Participated in CRPAQS winter program
- Ambient sampling in Fresno and Angiola
  - Fresno: urban site, total of 1,861,319 particles
  - Angiola: rural site, total of 2,099,788 particles
  - different chemical matrices due to aging effect
- Goal: quantitatively compare ambient particle size and chemical composition in urban and rural locations
Aerosol Time-of-Flight Mass Spectrometer (ATOFMS)

- Diode Pumped Nd:YAG Lasers
- Ellipsoidal Mirrors
- PMTs
- Particles

- $C_nH_m^+$, (Fe, V, Pb)$^+$
- $C_nH_m^-$, Nitrates, sulfates, phosphates, chloride
Can ATOFMS Provide Quantitative Information?

- ATOFMS unscaled counts capture ambient particle concentration information

- Scale ATOFMS unscaled particle counts with reference measurements
  - Mass: scale with MOUDI
  - Number: scale with APS
ATOF-M vs. BAM

\[ R^2 = 0.79 \]

Scale with APS

- Compare ATOFMS counts with APS # concentrations (size range 0.5-2.5 \(\mu m\))

- Scaling factor \((f)\):
  - \(f = \text{APS Counts} / \text{ATOFMS Counts}\)
  - exponential regression and polynomial regression
    - when \(Da < 1.783\ \mu m\):
      \[\varphi = C_1 \cdot e^{(D_a \cdot C_2)}\]
    - when \(Da \geq 1.783\ \mu m\):
      \[\varphi = C_3 \cdot D_a^2 - C_4 \cdot D_a + C_5\]
Scaled Mass Concentration

- Convert ATOFMS counts into mass conc.
  - assume all particles are spherical
  - assume uniform density of 1.3 g·cm$^{-3}$
- Calculate scaling factor for individual particle
- Scaled ATOFMS mass concentration – ATOF-N:

$$m_{scaled\_ATOFMS} = \sum_i \phi_{Da,i} \cdot m_i$$
ATOF-N vs. BAM

Fresno

\[ R^2 = 0.73 \]

Angiola

\[ R^2 = 0.80 \]
PM2.5 Measurements

• Fresno Site

  Nephelometer (NEPH)  Aethelometer (AETH)
  Beta attenuation monitor (BAM)
  Tapered element oscillating microbalance (TEOM)
  Dust aerosol monitor (DAM)
  ATOFMS mass conc. scaled with APS (ATOF-N)

• Angiola Site

  NEPH   AETH   BAM   ATOF-N
## Fresno PM2.5 Measurements Comparison

<table>
<thead>
<tr>
<th>R2</th>
<th>BAM</th>
<th>TEOM</th>
<th>DAM</th>
<th>NEPH</th>
<th>AETH</th>
<th>ATOF-N</th>
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<tbody>
<tr>
<td>BAM</td>
<td>1.00</td>
<td>0.86</td>
<td>0.93</td>
<td>0.75</td>
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<tr>
<td>TEOM</td>
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<td>0.60</td>
<td>0.94</td>
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<tr>
<td>DAM</td>
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<tr>
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<td>0.70</td>
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<td>AETH</td>
<td>0.79</td>
<td>0.94</td>
<td>0.53</td>
<td>0.58</td>
<td>1.00</td>
<td>0.59</td>
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<tr>
<td>ATOF-N</td>
<td>0.73</td>
<td>0.57</td>
<td>0.73</td>
<td>0.78</td>
<td>0.59</td>
<td>1.00</td>
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## Angiola PM2.5 Measurements Comparison

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<tr>
<td>ATOF-N</td>
<td>0.80</td>
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Fresno Temporal Variation of Chemical Types

[Graph showing mass concentration over time for different chemical types]
Fresno Temporal Variation of Chemical Types

The graph shows the temporal variation of chemical types in Fresno. The x-axis represents the date and time, starting from January 9th to February 4th. The y-axis represents the mass fraction ranging from 0% to 100%. Different chemical types are indicated by various colors and line styles:
- SVOC (brown)
- Biomass (purple)
- AgedOC (tan)
- AgedSalt (light blue)
- FreshSalt (red)
- Dust (dark blue)
- Ecoc (green)
- NH4_30_OC (orange)
- UnClass (magenta)

The graph illustrates how the mass fraction of each chemical type changes over time, providing insights into the temporal variation of chemical types in Fresno.
Conclusions

- ATOFMS is able to provide size resolved, high temporal resolution, and quantitative information on ambient PM composition.

- Carbonaceous particles account for more than 80% of the PM2.5 mass fraction in both Fresno and Angiola during the winter.

- Higher fraction of fresh biomass emissions in Fresno.

- Episodic periods with high amounts of ammonium and nitrate particles in Angiola.

- Diurnal variation of particle chemistry
  - Fresno: SVOC, biomass and aged OC peak at night. EC/OC and NH$_4$NO$_3$-OC peak during the day.
  - Angiola: PM with high levels of ammonium nitrate peak during day.

- To understand chemical variability and transformations will begin making comparisons with models (M. Kleeman, UC Davis).
Acknowledgements

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Dr. George Khairallah  Dr. David T. Suess

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California Air Resources Board
Angiola Temporal Variation of Chemical Types

- Biomass
- AgedOC
- AgedSalt
- Dust
- Ecoc
- w/ NH4NO3
- UnClass

Mass Concentration (ug m⁻³)

Graph showing the temporal variation of chemical types with specific dates and concentration levels.
Angiola Temporal Variation of Chemical Types